Renque

DISCRETE EVENT SIMULATION

User's guide

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Welcome to Renque

Renque is a powerful software environment designed for general-purpose discrete event simulations. It has a comprehensive graphical user interface and a versatile simulation engine, which enable you to rapidly build accurate simulations, for a wide range of applications.

The phrase simulation generally refers to a technique of imitating the behavior of some process or system by means of operating a project. Simulations are used to acquire numerical information and improve understanding of systems, in an environment where experimentation with the real system is undesirable or impossible.

Renque is a software tool developed to create and operate discrete event simulation models. A discrete event is something that happens in an instant of time, with zero duration. Although gradual system transitions can be represented in a Renque project, the program was designed primarily to deal with instantaneous changes.

Renque is a full-fledged *Microsoft Windows* application, suitable to analyze a virtually unlimited range of simulation objectives. Among the many helpful features that make modeling with Renque efficient and enjoyable are powerful animation tools, *Microsoft Excel* embedding, extensive charting possibilities, integrated calendar and scheduling tools, a helpful event viewer and *Microsoft Visual Basic* scripting.

In this document, the names of user interface controls are displayed in bold, where suitable. The names on Renque object properties are written with a capital letter, and property values are generally displayed in italic. Internal document hyperlinks are underlined.

Licensing and support

Renque is commercial software. A trial version, which can be used free of charge for a 14 day period, is available for download on the Renque website www.renque.com. Please visit the website for information about purchase and support options.

System requirements

Operating system:	*Microsoft Windows*™ XP or higher. Integration of *Microsoft Excel*™ is supported for version 97 and later.

1 Contents

2 Getting started

This section is intended to familiarize new users with the Renque simulation environment. It contains an introduction to the user interface and two tutorials:

▪ Quick start guide	Introduces the Renque user interface and the principles of simulation modeling in Renque.
▪ Tutorial 1	Demonstrates the construction and operation of a simple project for a small supermarket.
▪ Tutorial 2	Demonstrates the construction and operation of a project for an industrial production process.

2.1 Quick start guide

This topic contains an elementary tutorial that introduces the main features of Renque. You will visit and operate the most important elements of the user interface as you are guided through the construction of a very simple project.

When Renque is started it briefly displays an identifier splash window followed by the appearance of the primary user interface, recognized by the project name in the title bar of the window. Models are constructed and simulation runs are viewed on the Worksheet, which is the large blank area on this window. All other modeling tools and simulation controls are either located on the Main window as well, or accessible from it.

A Renque simulation has the three key elements: servers, links and entities.

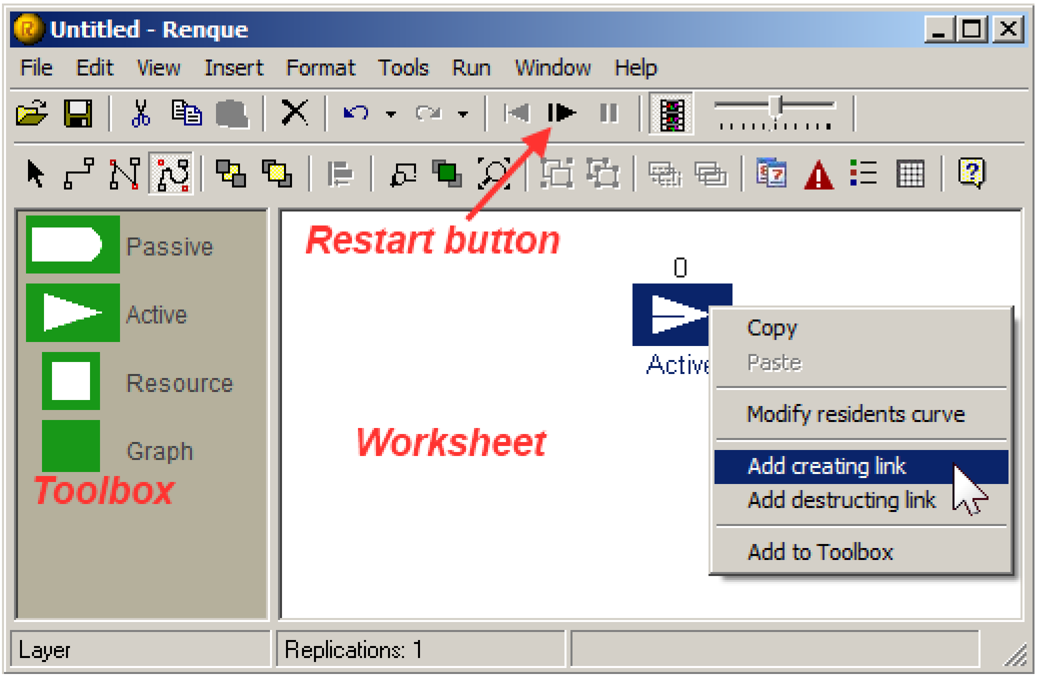
- Server objects act mainly as container and processor of entities. They are represented by static pictures in the Worksheet. Servers are created during the construction phase of the project.
- Links function as means to transport entities between servers and to create and destruct entities. Links are displayed on the Worksheet by curves.
- Entities are dynamic items in the project. As for servers, they are displayed as pictures on the Worksheet. However, entities are created and destructed during the simulation process, and they move around the project.

All project elements may or may not represent physical things found in the real world. If so, servers typically represent stationary objects such as machinery or storage facilities, whereas links are better suited to symbolize routes and roads. Entities are more likely to represent mobile or temporary objects such as materials or documents.

The available server templates are found in the Toolbox on the Main window, located on the left side of the Worksheet. To add a server to the project, simply use the mouse to drag the template from the Toolbox and drop it on the Worksheet. Links are created directly in the Worksheet by connecting two servers with the mouse.

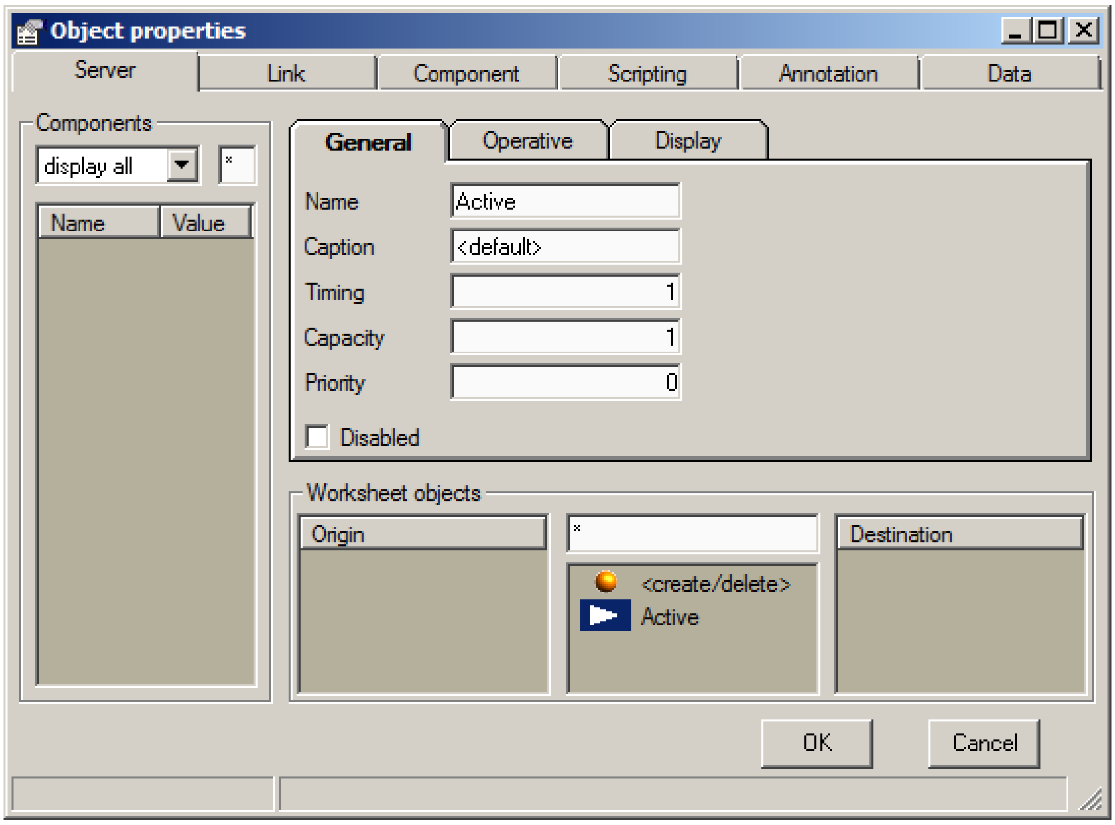
You can create a working project in the following three steps:
1. Create a server on the Worksheet by dragging the *Active* Template from the Toolbox and dropping it on the Worksheet.
2. Select the server by clicking on it, somewhere on the left-hand side.

3. Click on the selected ***Active*** server with the *right mouse button* to display a shortcut menu. Subsequently, click the menu command **Add creating link** to connect a link that creates entities to the server.



And there you are: You've created a Renque simulation project. Now, you can run a simulation by clicking the **Restart** button on the Toolbar at the top of the window. When the simulation is running, the animation speed can be altered by the **Animation speed slider** control on the Toolbar. The moving circle-shaped icons represent entities, traveling to the server after having been created on the link. Notice the simulation time advancing in the right-most pane of the three panes of the Status bar at the bottom of the window.

Stop the simulation by clicking the **Pause** button adjacent to the restart button. Now double-click the ***Active*** server on the Worksheet. A new window named Object properties is opened. This window serves as console to view and modify object properties.



Name	Active
Caption	<default>
Timing	1
Capacity	1
Priority	0

☐ Disabled

The middle of the three boxes at the bottom of the window indicates the selected state of the server in the Worksheet by the color of the icon. Notice the value 1 for the Timing property of the server. This value is the cause of the time increment observed during the simulation. The server forces the creation of an entity on the link, collects the entity from the link, and retains it for a period of 1 time unit. Thereafter, the entity is deleted because the server has no downstream links, so there is nothing else it can do with the entity.

The function of the object properties console depends on the selected tab item at the top of the window. Similar to the Server tab, the Link tab has a framed set of control items for properties of selected links. Simulation results, including various recorded statistics for the server, are viewed on the Data tab.

Next you are invited to extend the project with another server type from the Toolbox: *Passive*. Close the Object properties console by pressing **Cancel** to return to the Main window. Add a passive server to the **Worksheet** somewhere to the right of the previously created active server. Create a link between the two servers as follows: Move the mouse over the ***Active*** server until the mouse pointer changes to a different icon. Click on the ***Active*** server once, and a line appears that will follow the motion of the mouse. Move the mouse over the ***Passive*** server and verify that the mouse pointer changes once again. Now, click on the ***Passive*** server to create a new link. A straight line connecting the two servers will indicate the link.

Restart the simulation. In the animation you can see that the entities travel from the Active to the Passive server. On arrival at the Passive server the entities are stored in the server object. They are shown on a horizontal line, on the left side of the server picture. The number of stored entities that are displayed is limited by how many fit on this residents curve. The counter above the server picture indicates the actual number of entities stored.

Subsequently, **pause** the simulation and double-click the ***Passive*** server to display the Object properties console again. Notice that the property fields for **Timing** and **Capacity** are blank. These settings make sure that the server stores and retains every entity it receives.

The active and passive server classes are central in the Renque simulation engine. Active servers collect entities upstream via one or more connected links. The collected entities are stored in the server for a specified delay time. After that, the entities are dispatched to other servers along the links connected at the downstream side. Active servers repeat this sequence of actions in cycles. In contrast, passive servers do not collect nor dispatch entities. They simply store arriving entities to await collection by a downstream active server. A detailed description of the simulation mechanism is available in the Simulation engine reference section.

The other two server templates in the worksheet, Resource and Graph, have other functions in a simulation model. Resource servers provide shared resources to active servers. Graph servers are used to illustrate a model with graphics, text or data charts.

Renque also has a number of object types that are not displayed on the Worksheet. These objects are referred to as components, and can be applied to expand the capabilities of a project in various ways: Attribute and variable components are used to store data, distribution components provide random variation to a project, and schedule components perform actions at specified time points in a simulation.

The flow of entities through the project's server and link objects is controlled by a range of object properties, such as the previously mentioned Timing and Capacity properties. Although close approximation of a Renque project to the actual system is generally attainable with the available set of adaptable object properties, exact matching can not always be accomplished in the diverse intricacy of real systems. For this reason, a simulation project may be refined by the application of scripting. Scripts are short user-defined commands, invoked by specific incidents in a simulation. As all simulation procedures and object properties are accessible by scripting, the scripting feature provides the designer with an all-purpose tool to precisely impose the desired project behavior.

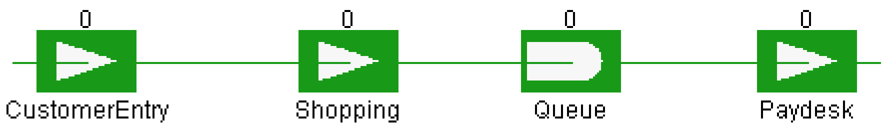
This document contains two more tutorials, which are intended to familiarize the user with the most important user interface items. These tutorials also demonstrate the application of scripting and components, and introduce some commonly applied simulation modeling methods.

2.2 Tutorial 1

This tutorial comprises construction and operation of a simple project for a small supermarket. The level of detail applied to the description of the required user actions presumes that the reader is familiar with the content of the Quick start guide section of this document. The tutorial demonstrates server and link properties control, and interpretation of simulation results within a practical context. Also, it introduces the application of components to add randomness to the project and to store data in entities. In addition, it will explain how to use the charting feature and apply scripts to refine the project.

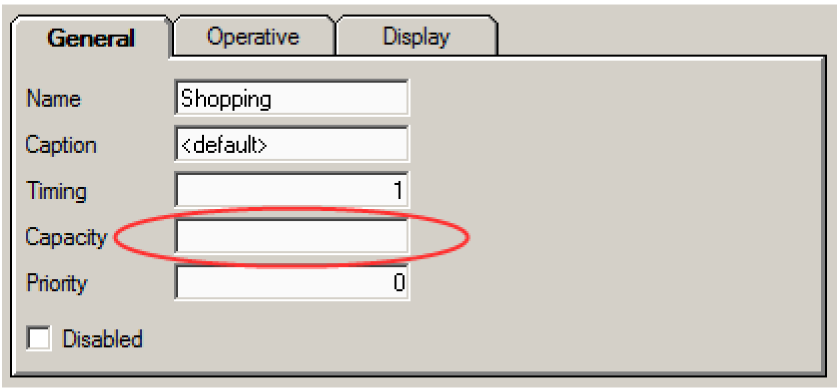
Imagine a supermarket where costumers arrive, spend some time shopping, choose a pay desk, wait their turn, and then check out and leave. Suppose the manager of the supermarket would like to know more about how the waiting time of the costumers for the check-out routine depends on the number of pay desk operators put into action. This tutorial demonstrates how to go about in building a Renque project for the supermarket and extract this kind of information from it.

Start the Renque application and create the project displayed in the figure, consisting of three active and a passive server object and five links. The server names are assigned by double-clicking a server and typing the desired text into the Name property text field of the Object properties console.



In this project the server named CostumerEntry is active and has a creating link. The server will repetitively force the creation of an entity on the link, store it for a specified period of time and then release it. As a result, it produces a flow of entities, with a release interval time determined by the Timing property of the server. In the project, these entities represent the customers arriving at the supermarket. The customer entities released by the CostumerEntry server are sent to the Shopping server where they are also stored for a specified time. This delay represents the time spent shopping by the customers. Upon release by the Shopping server the entities are sent to the passive Queue server, where they will be stored until the Paydesk server removes them. The Paydesk server is employed to project the check-out process by application of another delay. Finally the entities are sent to the destructing link, where they are removed from the project, representing the departure of the customers from the shop.

The next step of this tutorial involves manipulation of server properties to obtain the desired behavior of the project. Double-click the ***Shopping*** server to open the Object properties console and assign the *Void* value to the **Capacity** property on the **General** tab by clearing the associated text field.

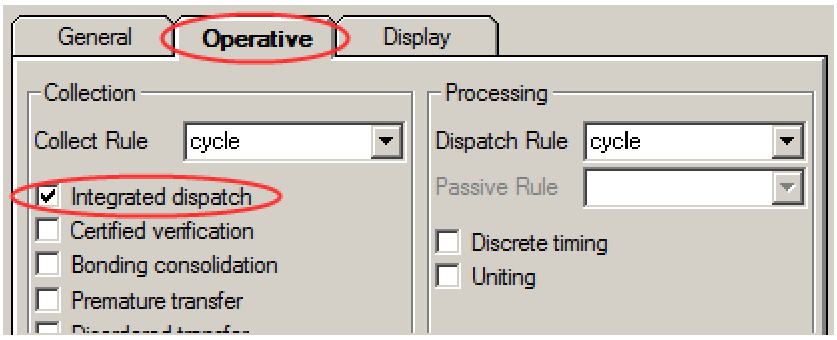


Name	Shopping
Caption	<default>
Timing	1
Capacity	
Priority	0

☐ Disabled

The *Void* Capacity value results into removal of the Capacity limit from the server. The Shopping server can now process an unlimited number of customers simultaneously.

Now select the ***CustomerEntry*** and ***Paydesk*** servers, and double-click one of them. Click the **Operative tab** in the Object properties console to access some more advanced server properties. Check the **Integrated dispatch** check box that appears on this tab.



Collect Rule: cycle

☑ Integrated dispatch
☐ Certified verification
☐ Bonding consolidation
☐ Premature transfer

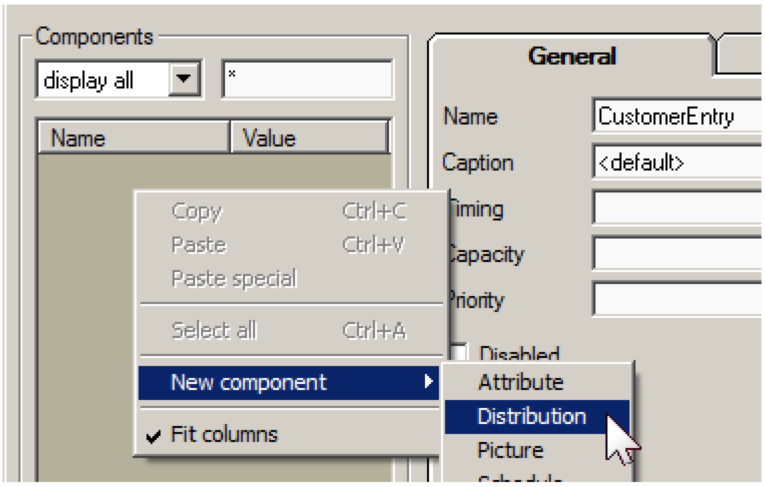
Dispatch Rule: cycle
Passive Rule:

☐ Discrete timing
☐ Uniting

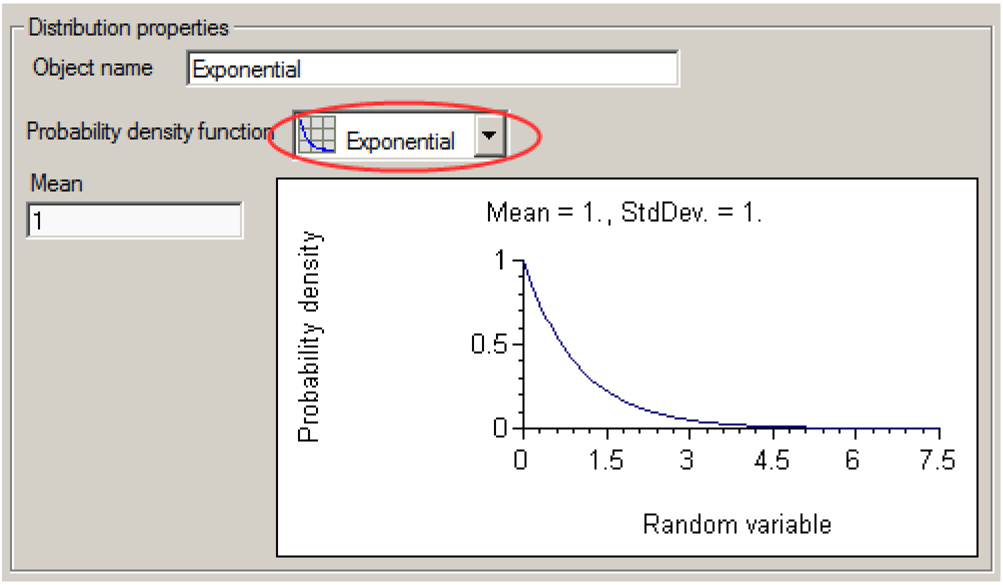
The Integrated dispatch option prevents a server from collecting new entities until the entities stored in the server have been dispatched. For the Paydesk server, this option makes sure that customer entities stay in the Queue server until the checkout process is complete. Without the option, the next customer entity is already transferred to the link buffer while the checkout process is still in progress for the previous customer.

Next, we focus on the CustomerEntry server. As discussed above, the server will release single customer entities with an interval time equal to the Timing property of the server, which has a value 1 by default. In reality, the customer interarrival times at the supermarket will not be uniform, however. Statistics theory dictates that the interarrival times of such processes are best described by an exponential probability density function.

Renque provides functionality for distributed random variation of properties by means of distribution components. In order to attain the desired exponentially distributed delay of entities in the CustomerEntry server, do the following: Double-click the ***CustomerEntry*** server to open the Object properties console by. In the Components frame, which is located on the left-hand side of the Object properties console, right-click the **Component repository** and select the **New component/Distribution** item from the pop-up menu.



This action creates a new distribution component, which appears as selected item in the Component repository. Select the **Component tab** at the top right of the window to view the properties of the new distribution component. Change the Probability density function of the component by selecting the *Exponential* item in the combo box, and pressing the **Enter key**. Keep the default value *1* for the Mean property.


Distribution properties

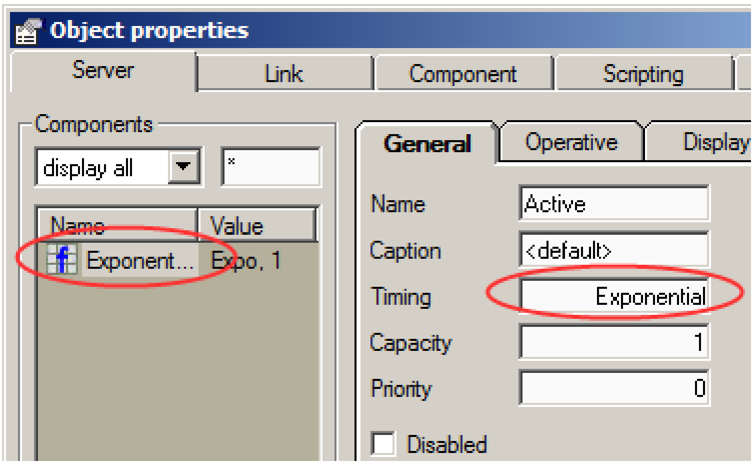
Object name: Exponential

Probability density function: Exponential

Mean: 1

As shown above, the Distribution properties frame contains a plot of the probability density as function of the random variable. In the supermarket scenario the random variable is the customer interarrival time. The frequency of occurrence of a specific interarrival time value is proportional to the probability density. The curve exhibits that simultaneous arrival of two customers (random variable = 0) is the most likely event to occur, because it has the highest probability density. Furthermore, the probability of occurrence decreases rapidly with growing interarrival time.

Return to the **Server tab** and assign the distribution component to the **Timing** property of the selected server by dragging the component item from the repository and dropping it onto the Timing text field, or by typing the component name in the text field. Press the **OK button**.



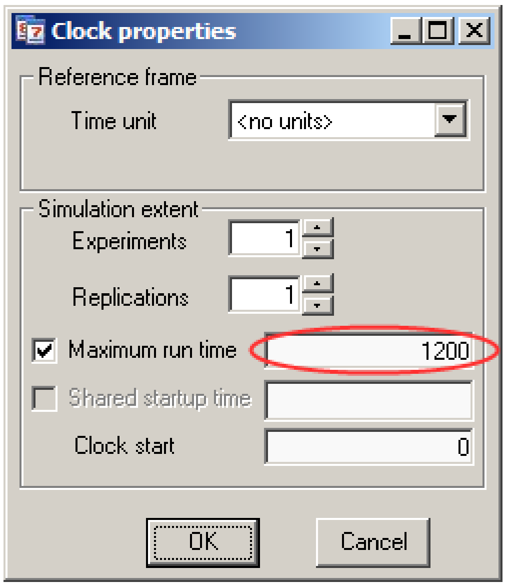
Name: Active
Caption: <default>
Timing: Exponential
Capacity: 1
Priority: 0
Disabled

You have created a new distribution component, named Exponential, of type *Exponential* with parameter *mean* = 1 and assigned it to the Timing property of the CustomerEntry server. As a result, each time an entity is collected from the creating link and stored in the server, its' residence time is set to a value generated by the Exponential component. The component produces random numbers distributed in accordance with the mean property, using a built-in random number generator.

Next, following the same procedure, create a distribution component of type *Triangular* with properties (min, mod, max) = (1, 5, 20) and assign it to the **Timing** property of the ***Shopping*** server. This modification makes the Timing property of the Shopping server random, in accordance with a triangular probability density distribution with a minimum, modal and maximum value of respectively 1, 5 and 20 time units.

The Paydesk server represents the check-out procedure. Double-click the ***Paydesk*** server and type a value *0.9* in the **Timing** property text field. In reality the checkout time will also show random variation and there will be some correlation with the shopping time. However, for now a uniform checkout time is applied. The value 0.9 renders the customer processing capacity 10% higher than the average customer arrival rate, imposed by the Exponential distribution component. Press the **OK button**.

Before running the project the simulation runtime is set. We assume that the time unit for the project is minutes. Select the **Clock** command from the **Tools menu**. Select the **Maximum run time** option in the Clock properties console and enter the value *1200* (5 days) in the associated text field. For the present project it in not necessary to select the *Minutes* value for the Time unit property. Press the **OK button**.



Reference frame

Time unit: <no units>

Simulation extent

Experiments: 1

Replications: 1

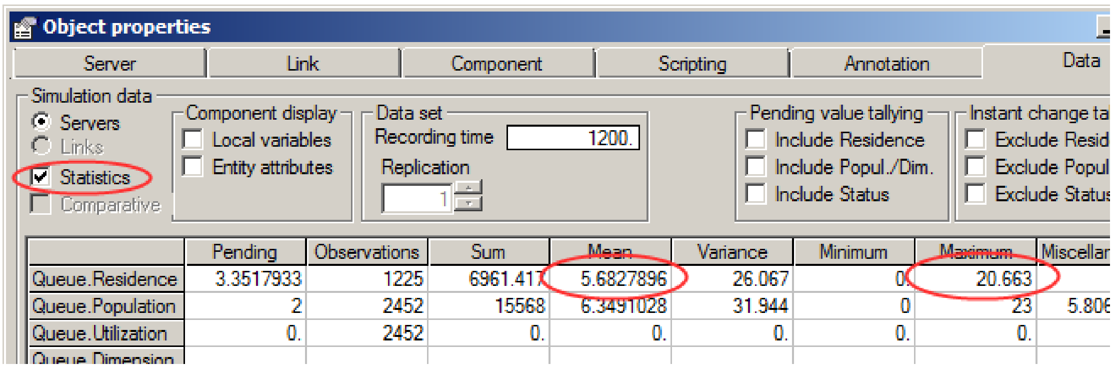
[✓] Maximum run time: 1200

[ ] Shared startup time

Clock start: 0

The simulation project for the supermarket, although still quite rudimental, is now ready to be run. Turn the **animation mode on** and press the **Restart** button. Watch the Shopping server initially filling up to some 10 customers, after which the first customers start arriving in the empty Queue to check out at the pay desk and leave. After running the project for a while the number of costumers shopping and queuing vary continuously. At first glance, the simulation project appears realistic.

Turn the **animation mode off** and let the simulation continue until it stops. Double-click the ***Queue*** server, select the **Data tab,** and check the **Statistics** option. The Object properties console now displays a grid-like sheet, which displays a set of recorded statistics for the Queue server.



Simulation data: [✓ Servers] Links [✓] Statistics [ ] Comparative

Component display: [ ] Local variables [ ] Entity attributes

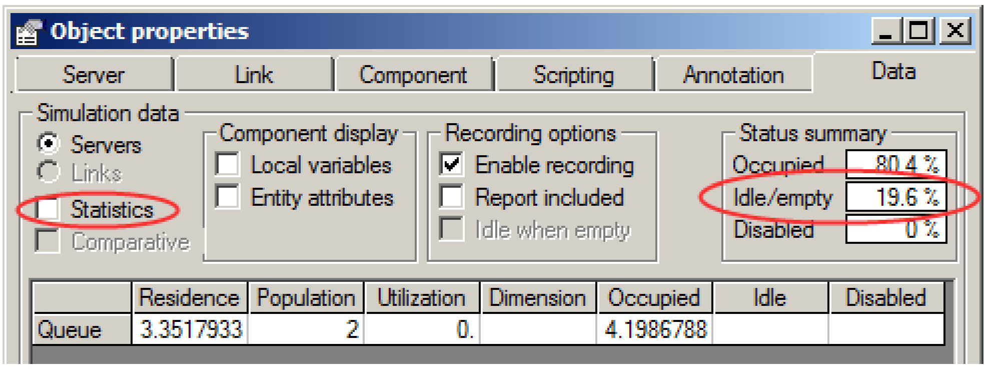
Data set: Recording time 1200. Replication 1

Pending value tallying: [ ] Include Residence [ ] Include Popul./Dim. [ ] Include Status

Instant change ta: [ ] Exclude Resid [ ] Exclude Popul [ ] Exclude Status

	Pending	Observations	Sum	Mean	Variance	Minimum	Maximum	Miscellar
Queue.Residence	3.3517933	1225	6961.417	5.6827896	26.067	0.	20.663	
Queue.Population	2	2452	15568	6.3491028	31.944	0	23	5.806
Queue.Utilization	0.	2452	0.	0.	0.	0.	0.	
Queue.Dimension								

In the top row of the data sheet, the column labeled *Maximum* reports a maximum residence time of 20.7 minutes. The reported **Mean** is 5.7 minutes. Uncheck the **Statistics** checkbox and observe that the queue is empty for less that 20% of the time, as indicated by **Idle/Empty** field of the Status summary sub-frame.


Object properties

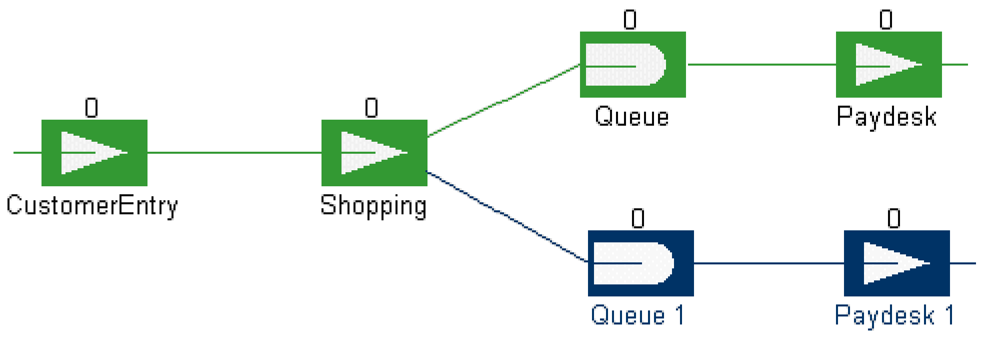
Server | Link | Component | Scripting | Annotation | Data

Simulation data: Servers [✓], Links, Statistics [ ], Comparative
Component display: Local variables [ ], Entity attributes [ ]
Recording options: Enable recording [✓], Report included [ ], Idle when empty [ ]
Status summary: Occupied 80.4 %, Idle/empty 19.6 %, Disabled 0 %

	Residence	Population	Utilization	Dimension	Occupied	Idle	Disabled
Queue	3.3517933	2	0.		4.1986788		

Obviously, the queuing times observed will be unacceptable to the clients of the supermarket. The excessive maximum results from the interarrival time distribution applied. The component creates busy next to quiet periods in the supermarket. As the pay desk capacity is fixed, customers queue up during the busy periods.

The next step of the tutorial demonstrates how to increase the number of pay desks in order to reduce customer queuing time. The simplest way to increasing the pay desk server processing capacity is to increase the Capacity property value. However this method is unsuitable because each pay desk has its own queue. Instead, select all server and link objects to the right of the shopping server. Move the mouse pointer onto the ***Paydesk*** server. Now, while keeping the **Ctrl key** on the keyboard pressed, drag the server downwards with the left mouse button to duplicate the selected objects. After a simulation reset the result should look similar to the project displayed in the figure below.



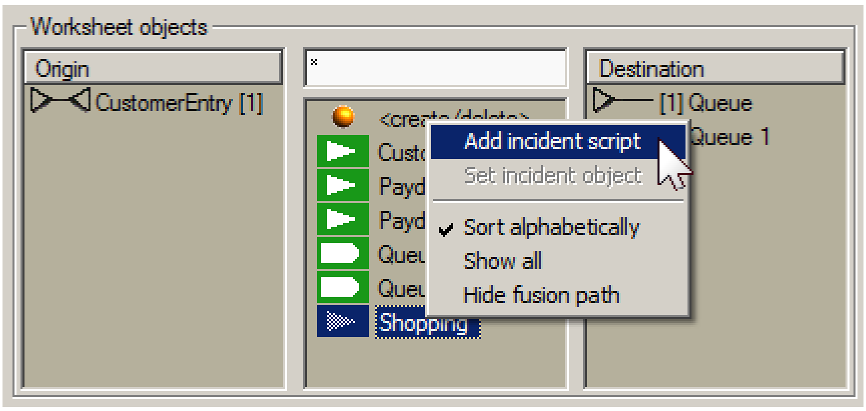
Restart the simulation and let it run until it stops. As expected, the waiting periods have been reduced significantly. You may verify that a mean value of some 0.14 minutes, or 8 seconds, and a maximum of some 2 minutes are reported for both queue servers. The improvement is obtained at the expense of the pay desk occupation, which has become about 46% on average for both pay desk servers. The latter may be verified by selecting and double-clicking each of the two pay desk servers, selecting the **Data tab** and inspecting the values reported in the **Occupied** field of the Status summary frame.

The next section of this tutorial enhances the project with shopping time dependent, random pay desk timing, using an attribute component and some incident scripts.

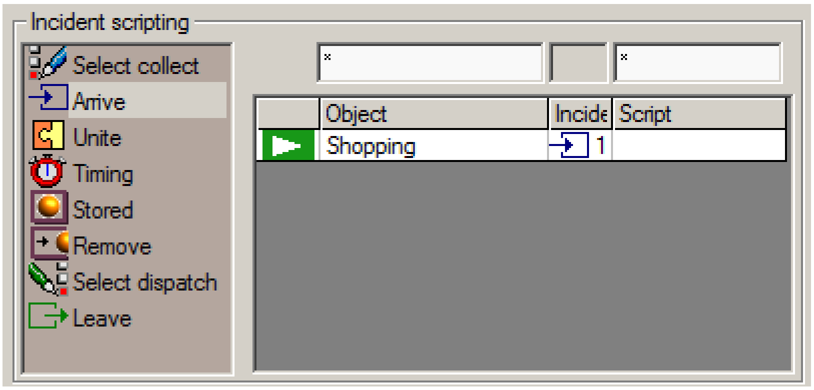
Also, the mechanism for queue selection by the customers will be refined and a chart will be created to inspect the number of queuing customers as a function of time.

Unselect all objects in the Worksheet by clicking in an empty area on the Worksheet. Double-click the ***Shopping*** server to open the Object properties console. Create a new attribute component by selecting the **New/Attribute** item in the pop-up menu **Component repository**. Rename the new attribute to *TShopping* by double-clicking the cell in the **Name column** of the Component repository, overtyping the default name and pressing the **Enter key**. A Renque attribute component allows storage of data in individual entities.

We will use the attribute to store the shopping time spent by a customer in the Shopping server into the entity representing the customer. Select the **Scripting tab** to display the Incident scripting frame. Select the **Arrive** item in the Incidents table on the left side of the frame. Then, in the Worksheet objects frame, at the bottom of the window, right-click the **Server browser** and select the **Add incident script** item from the pop-up menu.



This action will create a new incident script for the Shopping server, which is shown in the Incident grid, located at the right side of the Incident scripting frame.



	Object	Incide	Script
▶	Shopping	1	

Select the grid cell in the column titled **Script** and type or paste the following script:

```
TShopping = Triangular.eval
```

This script stores a random number generated by the Triangular distribution component in the TShopping attribute of entities arriving in the Shopping server. The Eval statement is used to store a number generated by the component, rather than the component itself, as object.

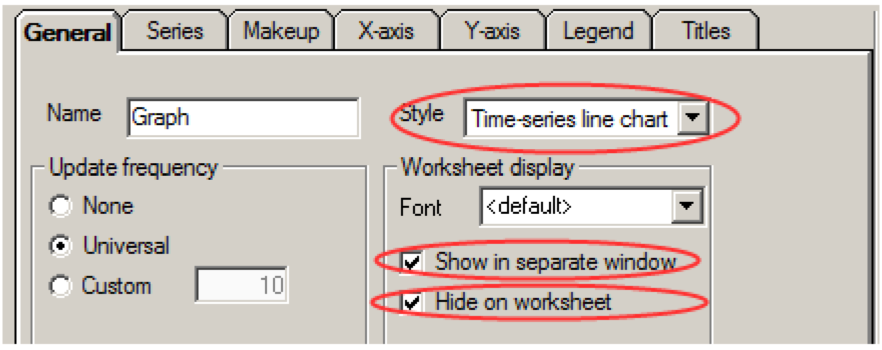
The TShopping attribute must now be assigned to the Timing property of the server, in place of the distribution component, in order to apply the time value stored in the attribute to the Shopping server delay. To do so, select the **Server tab** at the top of the window and drag-drop the ***TShopping*** attribute into the **Timing** text field. Press the **OK button**.

Next, we will modify the Timing property of the two pay desk servers. Select both Paydesk servers in the Worksheet. Double-click one of them to open the Object properties console. Create a new distribution component of type normal and keep the default parameter values. Assign the new distribution component to the selected servers by dragging it into Timing text field. Now, select the **Scripting tab** again and select **Timing** in the **Incidents table**. Right-click the **Server browser** and select the **Add incident scripts i**tem from the pop-up menu. Two new incident scripts are created, one for the each of the two servers. Select both in the column titled script' and type the following script:

```
Normal.ParametersSet 0.15 * TShopping,(0.015 * TShopping)^2
```

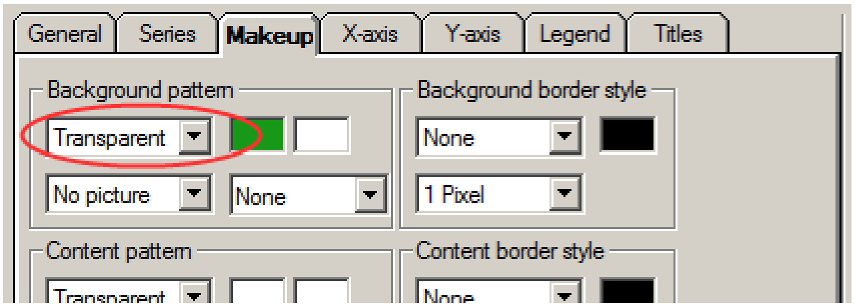
This script changes the parameters of the Normal distribution component, before the pay desk servers use it to generate a random number, which is to be applied to the storage time of the arriving entities. The mean value of the distribution component is set to 15% of the shopping time and the standard deviation is set to 1.5% of the shopping time (the variance parameter is the square of the standard deviation). Thus for each customer the checkout time will be assigned a random value, based on a normal probability density distribution with a mean value of 15% of the shopping time spent by that particular costumer.

Close the **Object properties console** and place a new server to the worksheet from the template **Graph**. Double-click the new server and the **Graph** tab, select the *Time series line chart* in the Style combo box. Also check the **Show in separate window** and **Hide on worksheet** option boxes.

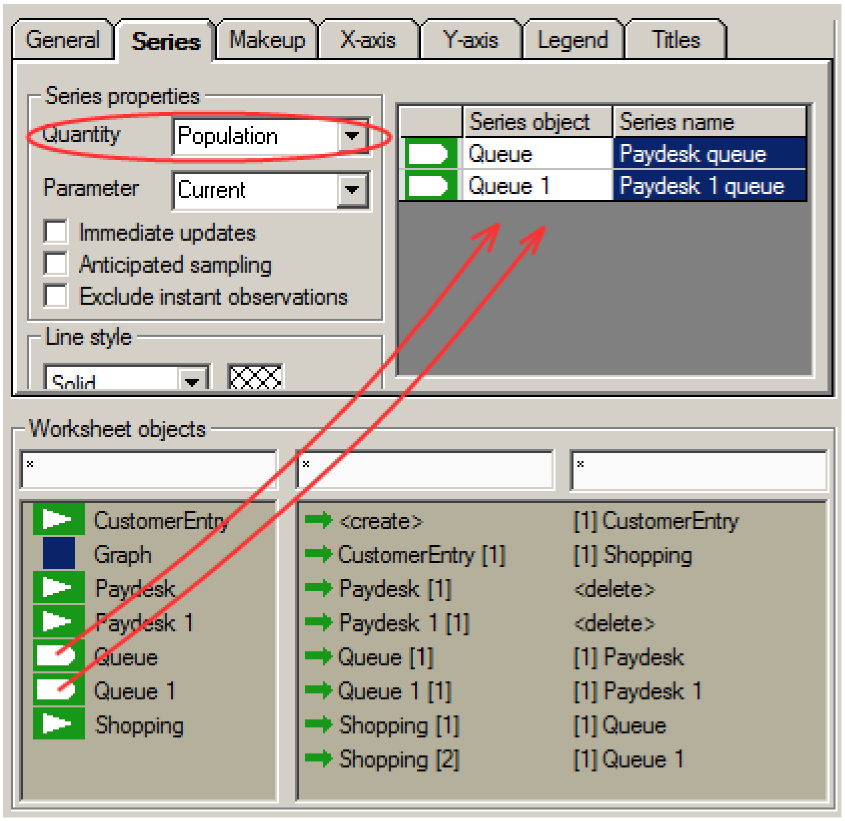


Name: Graph
Style: Time-series line chart
Update frequency: [✓ Universal]
Custom: 10
Font: <default>
[✓] Show in separate window
[✓] Hide on worksheet

Then select the **Makeup tab** on the top of the Graph tab page, and select the value *Transparent* for the **Background pattern** fill style.



Subsequently, select the Series tab on the top of the Graph tab page. Add a new data series to the graph server by dragging the ***Queue*** server item from the **Server browser** and dropping it into the empty space of the **Series grid**. Select *Population* from the **Quantity combo box**. In the grid cell of the column labeled *Series object*, change the series name from *Queue.population.current* to *Paydesk queue* by typing the new name in the grid cell. Add an identical **data series** for the ***Queue 1*** server, and change the name to *Paydesk 1 queue*.



	Series object	Series name
	Queue	Paydesk queue
	Queue 1	Paydesk 1 queue

The Graph server will display a data chart in a separate window, named *Graph*. The chart plots the number of customers waiting for their turn in each queue, as a function of time.

Restart the simulation, let it run until it stops and have a look at the chart. Observe the number of customers waiting in the queues varying in time. Notice that the two curves do not match very well. Considerable differences in the number of customers in the queues appear to occur frequently. In the real supermarket we expect the customers to join the shortest queue after being finished with shopping. Therefore the queues should typically have about the same length.

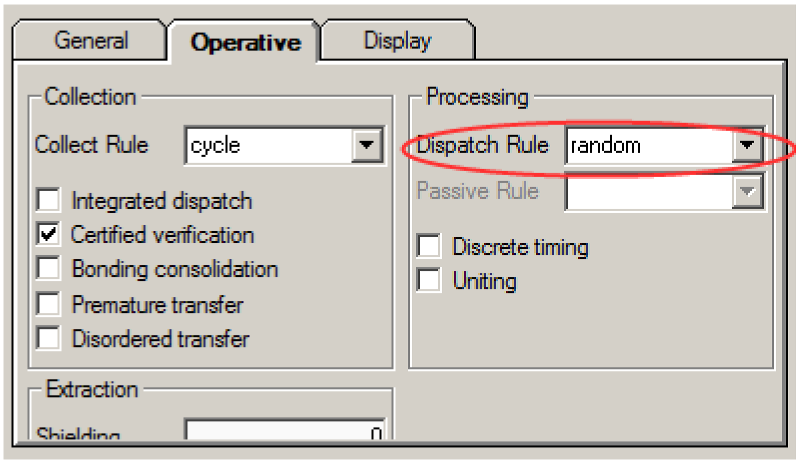
The cause for the contrasting behavior lies in the dispatch method of the Shopping server. The routing of entities from an active server is governed by the Dispatch Rule applied to the server. Because the Shopping server has the *Cycle* Dispatch rule, it sends released entities alternatingly to either queue, whereas dispatch to the link that connects to the queue server with the least number of residents is desired.

The dispatch routine can be refined by incident scripting. Double-click the ***Shopping*** server to open the Object properties console. Select the **Scripting tab** and create a new incident script of type **Select dispatch**. Assign the following script (by copy-paste, if you prefer):

```
if Queue.Population < Queue 1.Population then
Shopping.RuleLinks.SelectMember(1) else if Queue.Population >
Queue 1.Population then Shopping.RuleLinks.SelectMember(2)
```

This script forces selection of the link that connects to the queue server with the least number of residents. The `Population` function of a server object, used in the script, returns the number of residents. The `RuleLinks.SelectMember` procedure selects a link for the dispatch routine of an entity, overriding the link selection procedure governed by the Dispatch Rule property of the server. The arguments `1` and `2` denote the link connection number. An alternative and more compact script line could be applied here, using more advanced scripting procedures, but basic scripting statements are preferred for this first tutorial.

The script is ineffective if both queues have an equal number of residents. In that case the entity dispatch routine is determined by the Dispatch Rule. Click the **Server tab** at the top of the window, and subsequently the **Operative** tab. Select the *Random* value for the **Dispatch Rule** property in order to force the destination link of the entities released from the Shopping server to be selected randomly.



Collect Rule: cycle
Dispatch Rule: random
[ ] Integrated dispatch
[✓] Certified verification
[ ] Bonding consolidation
[ ] Premature transfer
[ ] Disordered transfer
[ ] Discrete timing
[ ] Uniting

Restart the simulation, let it run until it stops and look at the chart again. You can see that the curves are almost coinciding. The reported mean and maximum residence times on the data sheet are well below a minute for the mean and under 5 minutes for the maximum. The data reported for the Paydesk servers indicate that the average pay desk occupation is limited to approximately 69%.

One conclusion that the manager might come to using the Renque simulation project, is that substantial pay desk overcapacity is required to prevent loosing clients to competitors on waiting period annoyance. The obvious strategy to increase employee utilization is to assign pay desk operators to other duties during quiet periods, such as shelf stocking. Extension of the project for operator multi-tasking requires representation of the pay desk operators as resource entities. As modeling of resource sharing is subject of Tutorial 2, the present tutorial is concluded at this point.

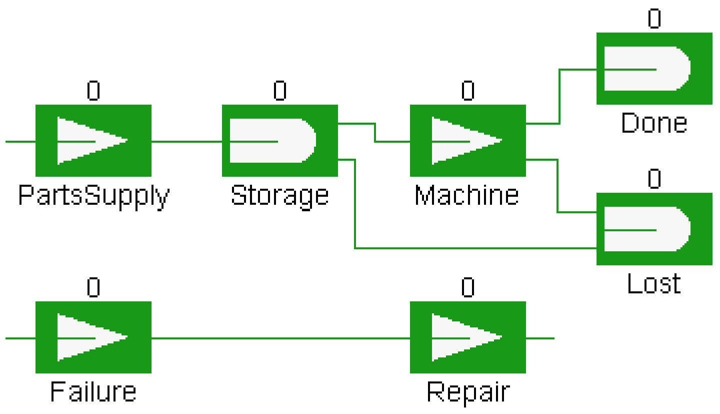
Simple as it may seem, the tutorial project for the supermarket is quite realistic. The data applied to the project parameters are fictitious, though. In order to reach a sufficient level of accuracy, these parameters need to be derived from data acquired from observations in the real supermarket or from suitable estimation methods.

2.3 Tutorial 2

This tutorial comprises the construction of a project for a section of an industrial production process. The focal point of the project is a single machine in a production line. The machine suffers occasional failures, which cause it to stop working. The machine can be restarted only after an operator has completed some repairs. The main purpose of the tutorial is to demonstrate a modeling technique for shared resources. It also introduces the application of schedule and variable components, and the use of picture components in animation design. The level of detail applied to the description of the required user actions presumes that the reader is familiar with the content of Tutorial 1.

Consider a machine in a production line of a factory, which performs a mechanical operation on a part. The machine receives input of parts from the preceding manufacturing step of the production line at a constant rate. From time to time the machine breaks down, which results into loss of the part being processed. Such failures require the attendance of a technician for repairs. The arrival of parts continues regardless of the state of the machine. Arriving parts that cannot be accepted by the machine are temporarily stored in a dedicated space. The available storage space is limited to five parts. All arriving parts that cannot be stored are scrapped. Processing is resumed when the machine has successfully been repaired, starting with the parts that have been stored temporarily. The technicians responsible for repairs on the machine also have other duties in the factory, which include emerging repairs on other equipment and scheduled maintenance work. The maintenance work may be interrupted for machine repairs.

The project for this process is constructed in two stages. First, the machine section will be constructed, including the failure and repair arrangement. In the secondly stage the technician resource will be implemented, together with the additional duties for the technician. For the first stage, start a new case and create the project section as displayed in the figure.



Assign the following server properties:

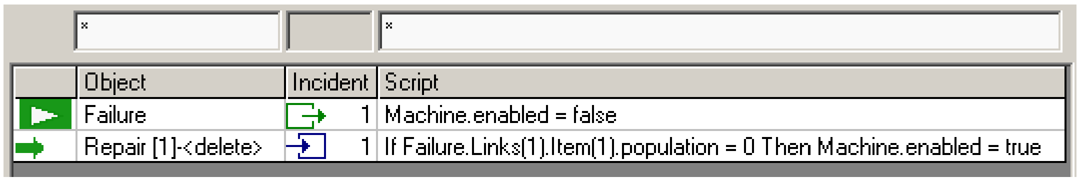
PartsSupply:	Timing =1.2
Storage:	Capacity = 5
Failure:	Timing = 100
Repair:	Timing =10
Machine:	Integrated dispatch

Assign the following link properties:

Storage-Lost:	Overflow recipient
Machine-Lost:	Discard recipient, Escort, Independent

The project created thus far includes the machine with supply of parts and the storage area, as well as failures and the resulting loss of parts and reparation. The server names reflect the function in the project. The PartsSupply server creates a flow of entities, which represent the parts to be processed. The parts are stored in the Storage server. The Machine server collects the parts from the Storage server and sends them to the Done server, after applying a delay to act for the processing time. The link from the Machine server to the Lost server is excluded from the regular dispatch routine of the Machine server, because of the combined application of the link properties Escort and Independent. The Escort property prevents this link from being selected for dispatch by the *Cycle* Dispatch Rule. As a result, under normal operation conditions, the entities representing the parts are all sent to the Done server. The Independent property of the other link prevents the creation and release of escort copies of the dispatched part entity to the Lost server.

The breakdown and repair actions for the Machine server are effectuated through scripting. To implement these actions, create two incident scripts as shown in the figure below.

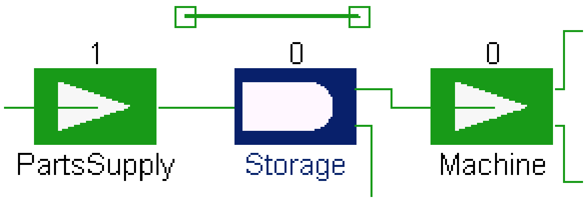


Object	Incident	Script
Failure	1	Machine.enabled = false
Repair [1]-<delete>	1	If Failure.Links(1).Item(1).population = 0 Then Machine.enabled = true

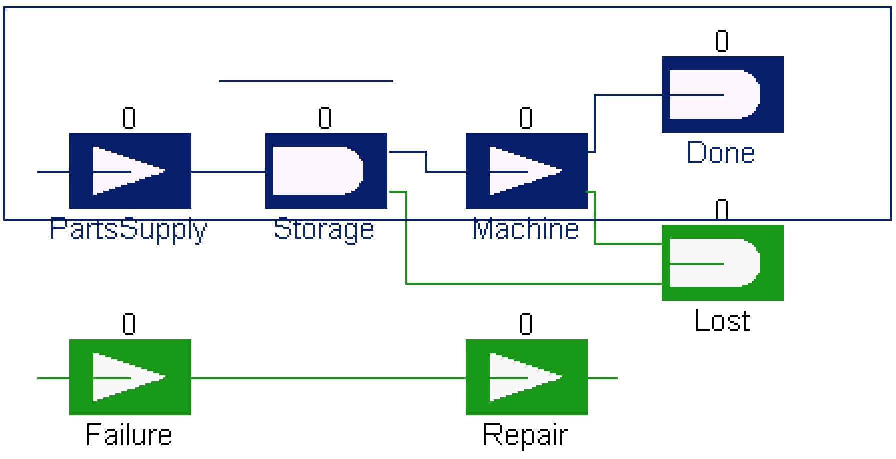
The `Enabled` function called in the first script affects the Disabled property of the Machine server. Disabling a server causes it to discard all stored entities and stop operating. If a Disabled server is enabled, it will resume normal operation by starting a new collection routine. The release of an entity from the Failure server disables the Machine server by the action of the first script. Parts that are consequently ejected from the Machine server are sent to the Lost server, because of the application of the Discard recipient property to the link connecting the Machine server to the Lost server. The failure entity is subsequently contained in the Repair server for a time period corresponding to the repair time. When released, the entity is sent to the destructing link, which re-enables the Machine server through the second script. The object description *Repair [1]-<delete>* refers to the destructing-type link of the Repair server. The script enables the Machine server, after verification that there no new failure entities have arrived.

During repair, the Machine server is Disabled and will therefore not collect any new entities. Because new parts continue to arrive, the capacity limit of the Storage server is reached after some time. Entities arriving when the Storage server is full are sent to the assigned Overflow recipient link, which is the link connected to the Lost server.

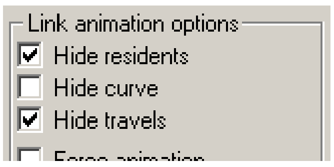
Before running the project, some modifications need to be made to the animation properties of the project. First, the Storage server residents curve is modified to allow display of all stored entities. Select the **Modify curve** item in the pop-up menu of the ***Storage*** server to enter the curve edit mode. Drag the two rectangular control points of the curve to reposition them as shown in the figure below. Click on an empty spot on the Worksheet, somewhere away from the control points to apply the changes and leave the curve edit mode.



Next, the travel animation needs to be disabled for some links. The simulation is focused on the impact of failures on the production rate attained by the machine. Because failures are relatively scarce, the animation will only be helpful if the animation features are also concentrated on failures and repairs. In order to accomplish this, select the set of server and link objects as displayed in the figure below. This can be done easily by drawing a selection box from left to right, as indicated in the figure, while keeping the left mouse button down. When the mouse-button is released, all objects inside the box are selected.



Double-click one of the selected objects, select the **Display tab** on the Link tab page and check the **Hide residents** and **Hide travels** properties in the animation properties frame.



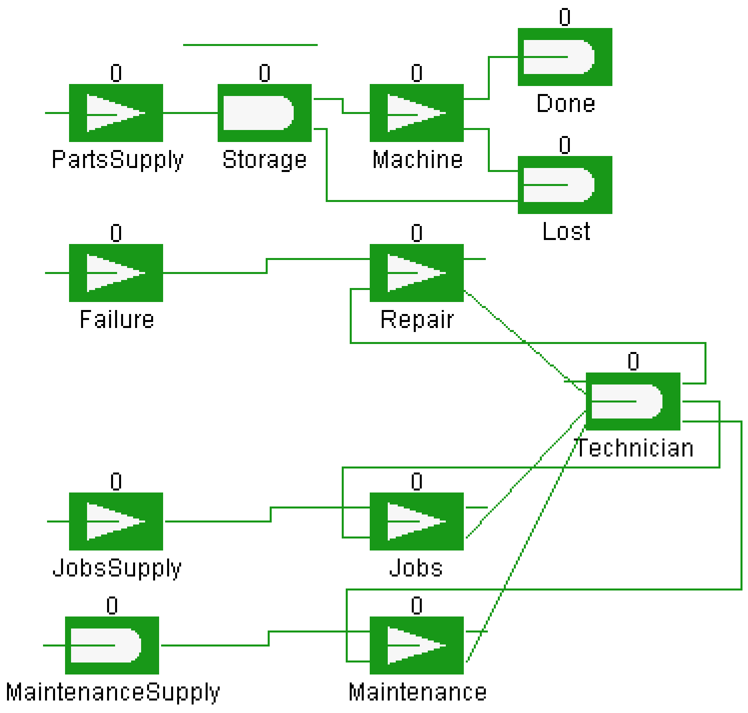
Link animation options
- [✓] Hide residents
- [ ] Hide curve
- [✓] Hide travels
- [ ] Force animation

Application of these options will prevent animation of entity traffic involved with normal machine manufacturing, as all selected links are associated with normal operation.

Run the project and view the animation. The Done server fills up rapidly and after 100 time units an entity is released from the Failure server. The entity stored in the

Machine server is released and travels to the Lost server. Then, while the Repair server is occupied, the number of entities contained in the Storage server grows to a total of 5, after which the Storage server also starts sending entities to the Lost server. After some time the Repair entity is released and the arrival of entities in the Done server continues. This scenario is repeated every 100 time units.

The next stage of this tutorial covers extension of the project with a shared technician resource, with repairing and other duties. Add the server and link objects displayed in the figure below. The connection order of links to a server can be altered by the **Move link** connection sub-items of the pop-up menu, which appears upon a right mouse click on a selected link.



Assign the following server properties:

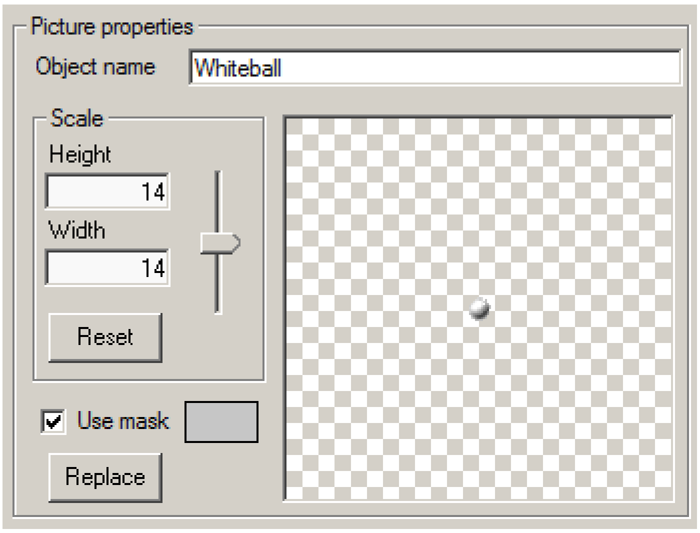
Failure:	Priority = 2
Repair:	Capacity = 2, Priority = 2, Shielding = 1, Revoking.
Technician:	Dispatch rule = *Order*, Priority = 2
JobsSupply:	Timing = 50, Priority =1
Jobs:	Timing = 10, Capacity = 2, Priority =1 , Shielding = 1, Revoking shield.
Maintenance:	Capacity = 2, Timing = 30, Bonding consolidation, Abortive interruption.

Assign the following link properties:

<create>-Technician:	Tracking
Technician-<all>:	Mandatory
<create>-MaintenanceSupply:	Not Initializing

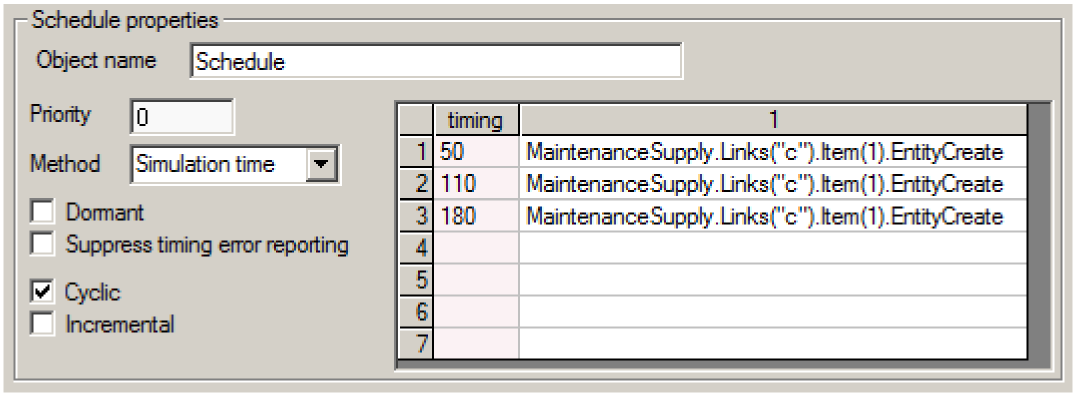
The Technician server represents a resource station. The server has a creating link, which generates a single entity at the start of the simulation. The server has dispatching links to the Repair, Jobs and Maintenance servers. These servers represent an activity that requires a technician to proceed. They all have the Capacity property value 2 and two collecting links. Of these, the top link is connected to the server from which the entity representing the duty is received. The lower collecting link has the Technician server as origin and has been assigned the Mandatory property. As a result, the three servers will only load the activity entity if the technician entity can be collected as well. On the dispatch side, the servers also have two dispatching links with the default dispatching-related properties. When the storage period elapses, the *Cycle* dispatch routine sends the first entity stored, which is the entity representing the duty, to the top dispatching link. This link is a destructing link, such that the duty entities are destroyed. The resource entity is sent to the second dispatching link, which returns the entity to the Technician server. This construction effectively causes the resource entity to be recycled, and forces the duty servers to compete for it. The priority values are assigned to determine the processing order if duty entities arrive at the same time. The *Order* value for the Dispatch rule property of the Technician server also arranges resource allocation priority.

To further enhance the animation, download a bitmap from the following web link: www.renque.com/downloads/images/whiteball.bmp and save it on your hard disk. The picture will be used to portray the resource entity. Double-click the Worksheet, and create a new picture component by selecting the **New/Picture** item of the pop-up menu of the **Component repository**. In the file selection utility that appears, select the downloaded bitmap file and press **Open**. Select the **Component tab** and click the small background area of the bitmap in the **Picture preview box**, in order to select the bitmap background color as transparency mask color.


Picture properties
Object name: Whiteball
Scale
Height: 14
Width: 14

The maintenance work is to be performed at predetermined, scheduled times. Let’s assume that the interval times are 50, 60 and 70 time units, in a repeating manner. In Renque, this can easily be modeled using a schedule component. Create a new schedule component by the **New/Schedule** item of the pop-up menu of the **Component repository**.

The new schedule, with the schedule lines to be added, is displayed in the figure below.



Schedule properties

Object name: Schedule

Priority: 0

Method: Simulation time

☐ Dormant

☐ Suppress timing error reporting

☑ Cyclic

☐ Incremental

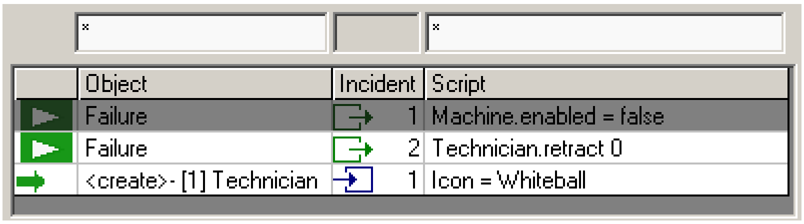
	timing	1
1	50	MaintenanceSupply.Links("c").Item(1).EntityCreate
2	110	MaintenanceSupply.Links("c").Item(1).EntityCreate
3	180	MaintenanceSupply.Links("c").Item(1).EntityCreate
4		
5		
6		
7		

The schedule has three identical scripts:

```
MaintenanceSupply.Links("c").Item(1).EntityCreate
```

The script forces the creation of a single entity on the creating link of the passive MaintenanceSupply server. This entity will be stored in the server for collection by the Maintenance server. Type or copy/paste this script in the schedule grid, type in the timing values given in the figure, and check the **Cyclic** property. The timing column of the schedule grid defines the simulation times for execution of the schedule scripts. The assumed repeating interval times (50, 60, 70) require execution of the script at simulation time values *50, 110, 180, 230, 290, 360...*and so on. The *Cyclic* property forces execution of the schedule to recommence from the top row after the last item in the list has been executed, and thus results into the desired time intervals.

Next, create two new incident scripts as displayed in the figure below.



Object	Incident	Script
Failure	1	Machine.enabled = false
Failure	2	Technician.retract 0
<create> - [1] Technician	1	Icon = Whiteball

The retract statement, called on the Technician server, causes entities created by a creating link under application of the Tracking property, to return to the link that created the entity. The Icon assignment script assigns the picture component named *whiteball* to the icon property of an arriving entity. As only the technician resource entity arrives on this link, the resource entity will be distinguishable from other entities in the animation.

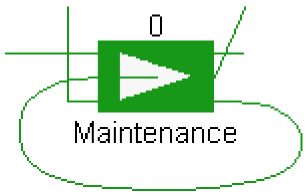
Now, run the project with the animation enabled. Watch the technician entity being collected by the Maintenance, Jobs and Repair servers. The technician entity is stored together with the duty entity in the server and sent back to the Technician server after processing. (If these servers do not display both entities on the residents curve, zoom-in on the viewport using the middle mouse-button while holding down the **Ctrl key**.)

To complete the project, place a new **graph server** on the worksheet. Double-click the server and create a **variable** component named *R*. Set the **Style** property of the graph server to *Time-series line chart*, and add a **Data series** for the current value of variable R, by drag-dropping the variable component onto the **series grid** of the series tab page. Also, create a new **Arrival incident script** for the ***Storage*** server:

```
R = Lost.Population / (Done.Population + Lost.Population)
```

This script evaluates the “scrap ratio”, i.e. the fraction of lost parts with respect to the total number of parts supplied, which is a measure for the performance of the machine. The result is stored in variable R, which is plotted in the chart.

Finally, a small project extension is added to return the discarded maintenance duty entities to the Maintenance server for completion of unfinished maintenance work. Create an **attribute** component named ***Tresidual***, and a new **link** as shown in the figure. The link should have the properties **Escort**, **Independent** and **Discard recipient**.



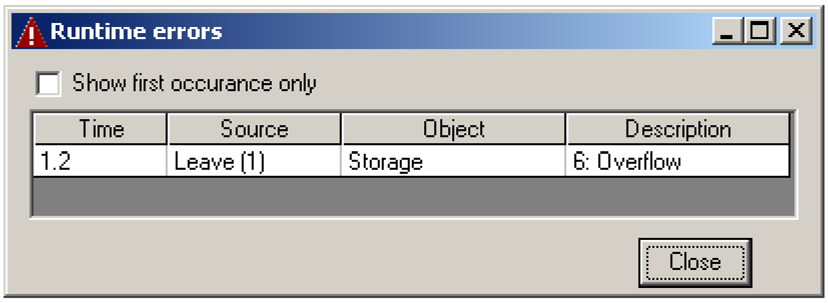
Also add two incident scripts to the ***Maintenance*** server:

Timing incident	`If .SelectedCollectingLink.DestinationIndex = 1 then .Timing = 30 else .Timing = Tresidual`
Remove incident:	`Tresidual = ScriptEntity.Departure - SimTime`

The second script assigns the remaining residence time to the Tresidual attribute of the duty entity when it is discarded by the Retract call. The first script assigns the attribute value of the duty entity to the server timing property if the duty entity is collected from the recycle link. With this extension, the Maintenance server will also process interrupted maintenance work.

Restart the simulation with animation enabled. At the simulation time value *200* a failure occurs while the resource entity is stored in the Maintenance server. The release of the failure entity from the Failure server causes a Retract call on the resource entity. The retraction removes the resource entity from the Maintenance server and sends it back to the Technician server. Because the Bonding consolidation option is applied to the Maintenance server, the duty entity is discarded to the recycling link. In case the technician resource is held by the Jobs or by the Repair server, the retract call is ineffective, because these servers have a Shielding value *1*, which outweighs the argument *0* of the `Retract` script statement. The Revoking property of the servers cancels the retraction call. As a result, the work is postponed until the resource entity becomes available again in the Technician server.

Now turn off the animation and let the simulation run for a while. The line in the chart shows abrupt changes in the slope each time a failure occurs. As the simulation proceeds, the “scrap fraction” R converges slowly to a value of about 0.05. Also click the **Tools/Runtime errors** item of the Menu bar to open the Runtime error viewer.



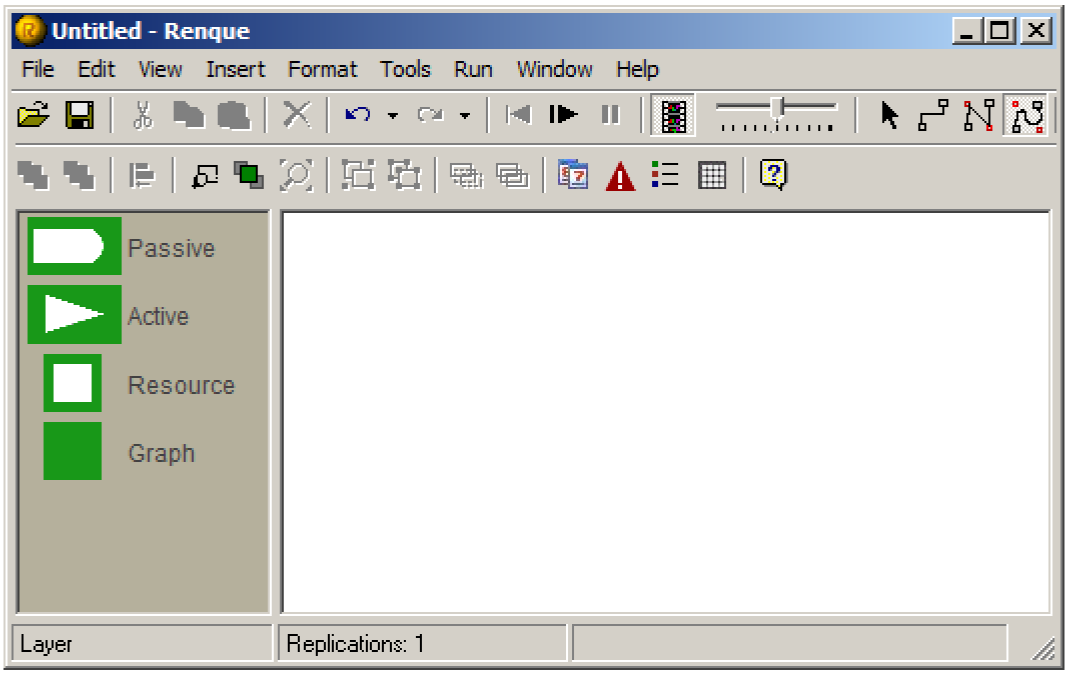
Time	Source	Object	Description
1.2	Leave (1)	Storage	6: Overflow

The Runtime error viewer displays an error caused by the Leave incident script of the Storage server. This error is caused by the division operation of the script, as both the Done and the Lost server are empty the first time the script is executed. In Renque, all script errors leave an entry in the Runtime error viewer, without causing the simulation to halt. The occurrence of this particular error is easily prevented. It was caused intentionally in this tutorial to demonstrate the function of the Runtime error viewer.

The use of random numbers has been omitted in this tutorial in order to make interpretation of the animation a little easier. If the project was for real, it would probably incorporate several distribution components, generating significant random variation. Even so, simulation models like this tutorial project are widely used for parameter sensitivity analysis and system optimization. The number of resources, the resource allocation priority, and the timing properties of servers and schedules may all be varied to obtain quantitative insight into how the machine performance can be improved by adjusting the conditions in the factory.

3 Model construction

Renque simulation models are constructed and operated primarily in the application's main window. The Main window is the principal user interface of the application. It is opened when the application is started, and the program exits when the Main window is closed.



This section has a topic discusses the Operation basics of the program and topics for each of the five elements of the Main window:

• Worksheet	Area for project construction and simulation animation.
• Toolbox	Contains pre-defined server templates.
• Menu bar	Categorized list of operation commands.
• Toolbar	Provides access to frequently used menu items.
• Status bar	Displays information on the status of a simulation and the active layer of the Worksheet.

3.1 Operation basics

Renque is a stand-alone *Microsoft Windows* application. Multiple instances of Renque may be started in a Windows session, but you can only have one project in a Renque instance at the same time. Most elements of a Renque project may be copy-pasted between Renque instances by standard Windows procedures.

Projects are opened and saved by the usual Windows commands **New**, **Open**, **Save** and **Save As**, which are available in the File menu of the Main window. Double-clicking a file with a Renque-associated file extension in Windows Explorer will open the file in a new Renque instance. Drag-dropping a file from Windows Explorer onto the Worksheet area of the Main window will open the file, after prompting to save the project being replaced. A Renque instance is closed by the Exit command on the File menu or by clicking on the ‘X’-button on the title bar of the Main window.

Renque project file types

There are two Renque project file types:

- The Renque project file (extension: *.rnq, icon: ●)
- The Renque presentation file (extension: *.rnqp, icon: ●)

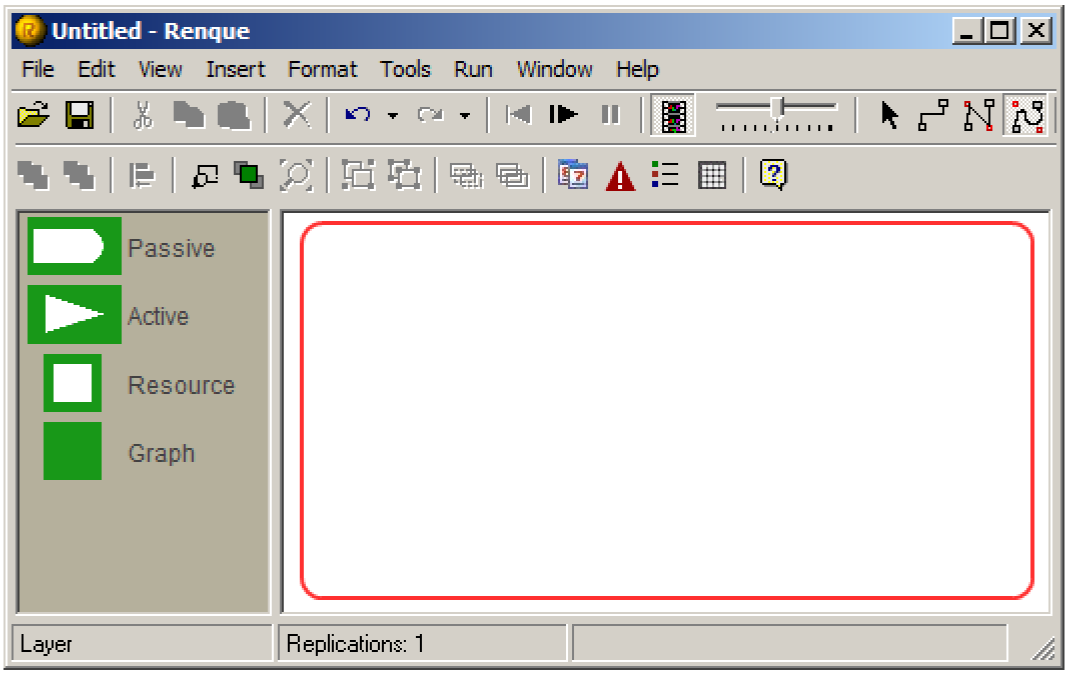
The Renque project file is the standard Renque project file type, recognized by the file extension *rnq*. This file type supports storage of all information that can be contained in a Renque simulation project, including bitmaps, embedded spreadsheets and all simulation data. This file type is either saved in text format or in binary format, depending on the Settings applied in the Files preferences.

The Renque presentation file has the default extension *rnqp.* It contains essentially the same information as the standard Renque project file, but is saved in a binary file format. It allows for distribution of Renque simulation models without disclosure of certain project details. When opened in Renque, a Presentation file can be viewed and operated as a standard Renque project. However, a Presentation project cannot be modified and the designer can prevent parts of the project from being displayed. A Renque presentation file can only be saved back as presentation file, whereas the standard Renque project file can be saved in both formats.

The **Save presentation** command in the File menu creates a presentation file for the current project. The presentation properties are controlled on the Presentation properties console.

3.2 Worksheet area

A Renque simulation project is constructed and operated in the Worksheet area, highlighted in the figure below.



The Worksheet offers a variety of methods for the construction and examination of a simulation model.

Server creation

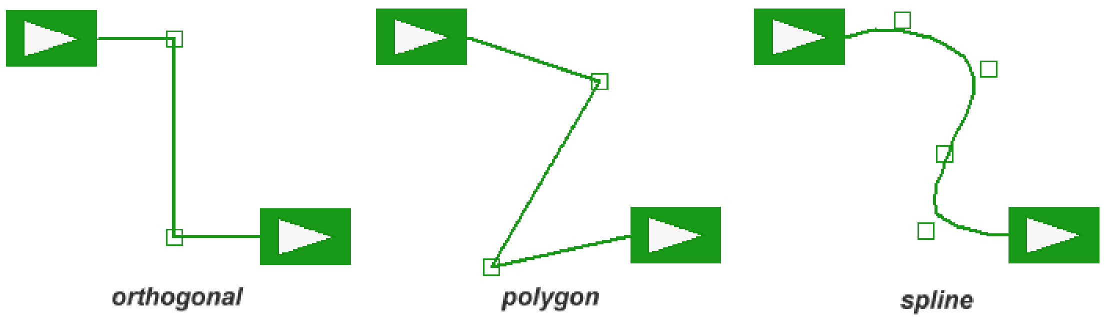
Servers are added to the model by drag-dropping a template from the Toolbox onto the **Worksheet**, using the mouse. Server objects added to the Worksheet are placed in the current layer.

Link creation

Links are created by clicking with the left mouse button successively on an origin and a destination server picture. To start link creation, the mouse must hit the **origin server** picture in an area closer than 1/3 of the picture width to the downstream edge. Clicking anywhere on the picture of the **destination server** will create the link, unless the **Ctrl key** is held down. If the pictures are clicked on in a transparent region the action has no effect. Links cannot be connected to Resource servers. Link objects created on the Worksheet are placed in the current layer.

Link curve types

Renque supports the link curve types *Spline*, *Polygon* and *Orthogonal*, which all have a distinct shape.



When a new link is created, the curve type is determined by the selected **Curve type** item in the Format menu. The path of a curve is determined by control points, which are visible only when a curve is being edited or created. When a link is being created, each click on an empty spot on the Worksheet results in addition of a control point. The curve types exist for animation purposes only: they have no logical distinctions. Once created, curves can be edited to add, remove and rearrange control points, and to change the curve type.

Object selection

Making changes to an object on the Worksheet first requires selection of the object. Selected objects on the Worksheet are indicated by the select status color of the operating system for the picture, label and curve of the object (for links only the curve).

Selection of a single object is simply done by clicking on it in the **Worksheet**. The selection result depends on the status of the **Ctrl key** and the **Shift key** on the keyboard during the selection operation.

Shift key state	***Ctrl key state***	***Selection result***
released	pressed	remove from selection
pressed	released	add to the selection
released	released	start new selection

To select/unselect several objects at the same time: Press the left mouse button on an empty location on the Worksheet and move the mouse while keeping the mouse button pressed. A rectangle is displayed to indicate the active region. The selection operation is executed when the mouse button is released. The result of this rectangular selection depends on the horizontal sweep direction. If the mouse was moved from left to right, only objects that lie completely inside the rectangle are affected. If the mouse is moved from right to left objects touching the rectangle are selected as well. The rules of the Ctrl and shift key status apply to this selection method in the same manner as to selection by mouse clicks.

If the mouse button is held down for at least half a second on a set of overlapping server pictures or identical links, the mouse pointer will change briefly to indicate that a list of overlapping selectable objects has been assembled. The list is displayed on the Worksheet when the mouse button is released. The selection status of the listed objects can be adjusted by selecting and unselecting items in the list. If the Worksheet is clicked again, the operation is applied and the list is removed.

In the Runtime display mode, objects can only be selected on the Worksheet if at least one object element that indicates the selection status is displayed. Thus, servers cannot be selected in the Runtime display mode if only the residents count is visible, and links cannot be selected if the link curve is hidden. Selecting an object that has been grouped with other objects, will select all members of the group, including objects that cannot be selected individually.

Object transformations

The following transformations can be performed on objects visible in the Worksheet, using the Menu bar or a pop-up menu on the Worksheet:

- Cut, copy & paste.
- Delete.
- Group objects to enable joint selection.
- Merge objects into a Fusions.
- Rearrange server locations.
- Resize servers.
- Change the display order of servers.
- Assign an object layer.

The position of servers on the Worksheet can be changed by dragging their picture across the Worksheet. If the control-button on the keyboard is pressed while starting the drag operation, the selected servers and selected connected links are duplicated. In that case, the duplicates are subjected to the drag operation. As opposed to the copy/paste menu commands, this duplication method does not store the objects in the Windows clipboard.

Server editing

A Server can be resized using the **Resize** command of the Format menu. This command is enabled if a server object has been selected by a mouse click. The Resize command switches the Worksheet to the server resize mode. In the resize mode, sizing handles are displayed on the edges of the server picture bounding box. Servers are resized by dragged the sizing handles with the mouse. In the resize mode for graph servers also allows adjustment of the Graph server layout. The server resize mode is terminated if the worksheet is clicked at dome distance from the sizing handles.

Curve editing

Link curves and server residents curves may be edited using the **Modify curve** command of the Format menu. This command is enabled if a link or server object has been selected by a mouse click. The Modify curve command switches the Worksheet to the curve edit mode. In the curve edit mode the control points of a curve are displayed on the Worksheet. A control point can be selected by the mouse and dragged to a different position on the Worksheet by. Pressing the **Delete** key removes the selected control point. Control points are inserted into a curve by clicking on the link at the desired insertion location, while keeping the **Ctrl key** pressed. The type of the curve being edited is changed by selecting another **Link type** item in the Format menu. The curve modifications are stored and the curve edit mode is terminated by pressing the **Enter key** or by clicking on the Worksheet at some distance from the curve being edited. Pressing the **Esc key** terminates the curve edit mode without storing any changes made to a curve.

Viewport transformations

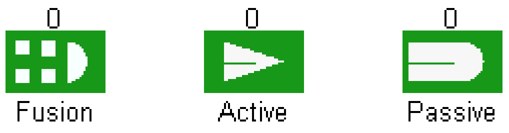
The viewport dimensions of the Worksheet may be scaled and translated using the mouse. The viewport is translated if the mouse is moved while keeping the **middle button** pressed. The same procedure results into dynamic scaling of the viewport if the **Ctrl key** is held down. On systems that have no middle mouse button, dynamic scaling and translating of the viewport can be performed in the same manner, but with the **right button**, while holding the **Shift key** down.

Runtime display mode

If a simulation is running, the display style of objects on the Worksheet can be different form the objects display style in the *Reset* status. In the *Running* status, the server Caption property is shown in the place of the Name property, and graphical elements of servers and links can be hidden on the Worksheet on the Display tab of the Object properties console. Enabling the Runtime display mode forces the display style of *Running* status to the Worksheet at all times. The **Runtime display** item on the View menu toggles between the normal and Runtime display modes.

Fusions

A set of objects on the Worksheet can be merged into a Fusion server object. The result of this operation is that the merged objects are no longer individually present on the Worksheet, but represented collectively by the Fusion server. Fusions are shown on the Worksheet in the same way as other server objects. Fusions have a distinct default picture, which has the same style and size as the pictures of the Active and Passive templates in the Toolbox.



Fusions are created by the **Fuse objects** command of the Format menu and removed by the **Unfuse** command. The **Fuse** command merges all selected objects on the Worksheet into a new Fusion server. The Unfuse command reverses this transformation for all Fusion servers selected on the Worksheet.

Fusion window

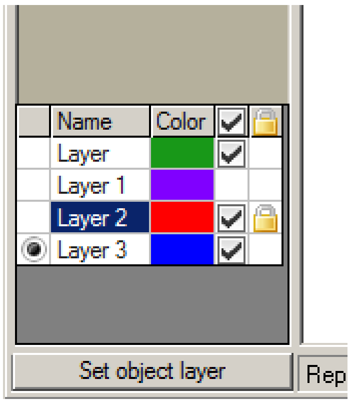
The constituents of above-mentioned fusion server type can be made accessible in a separate Fusion window. Fusion windows is opened by selecting the **Open Fusion windows** command of the Window menu. The Fusion window displays all objects that make part of the fusion server. The user interface of the Fusion window is highly similar to the Main window user interface. Some menu items of the Main window that are not relevant to fusion servers, have been left out of the Fusion window interface. The fusion constituents and their arrangement can be modified in the Worksheet of the Fusion window by the same methods as discussed in this section for the Main window. The fusion window also supports all animation features. A link that is connected to a fused operative server, but not fused itself, is shown connected to the fusion server.

Layers

The server and link objects on the Worksheet are organized in layers. The layers have a specified color, and may be locked and hidden. The main purpose of layers is to collect together a series of objects that are related in some meaningful way, for example by a common function in the model. The organization of a project into layers offers many advantages to the project designer. The ability to hide layers and to apply different colors to layers makes it easier to visualize objects collectively. Furthermore, layer locking is useful, for example, for large server pictures, used as background image, because objects in locked layers cannot be selected in the Worksheet.

New objects created on the Worksheet are placed in the layer that has been assigned active layer. The active or current layer can be identified in the Status bar and by the color of the default templates in the Toolbox.

The layers of a Renque project are managed by the Layer list. The Layer list is activated by a mouse click on the left-most panel of the Status bar or by the **Layers** command of the Tools menu. The Layer list is a pop-up control that presents a list of all layers defined for the project. It enables the creation and deletion of layers, modification of layer properties, and assignment of the current layer. It is also used to move objects on the worksheet to a different layer.



	Name	Color	✓	🔒
	Layer	🟩	✓	
	Layer 1	🟪		
	Layer 2	🟥	✓	🔒
●	Layer 3	🟦	✓	

The radio button icon in the first column of the Layer list indicates which layer is the **current layer** on the Worksheet. The radio button icon moves to another row if the first column is clicked with the mouse, which sets the current layer. The second column, labeled **Name**, displays the layer name. The layer name can be edited in-cell, by double clicking the name field or by pressing a key on the keyboard. The assigned name must be unique and has the same format requirements as the Name property of servers and components. The column labeled **Color** determines the default display color for objects contained in the layer. The layer color can be modified by a color selection utility, which is activated by clicking on the Color column. The two other columns display indicate additional layer properties by icons. The checkbox icon signifies that the layer is **visible**. Objects contained in hidden layers are not shown on the Worksheet, The padlock icon signifies that the layer is **locked**. Objects in locked layers are visible, but cannot be selected. Clicking either of the two leftmost columns toggles the corresponding layer property.

The **Set object layer** button appears on the Status bar when the Layer list is activated. By pressing this button, all selected server and link objects on the worksheet are placed in the selected layer in the Layer list. The button is disabled if multiple layer are selected in the Layer list.

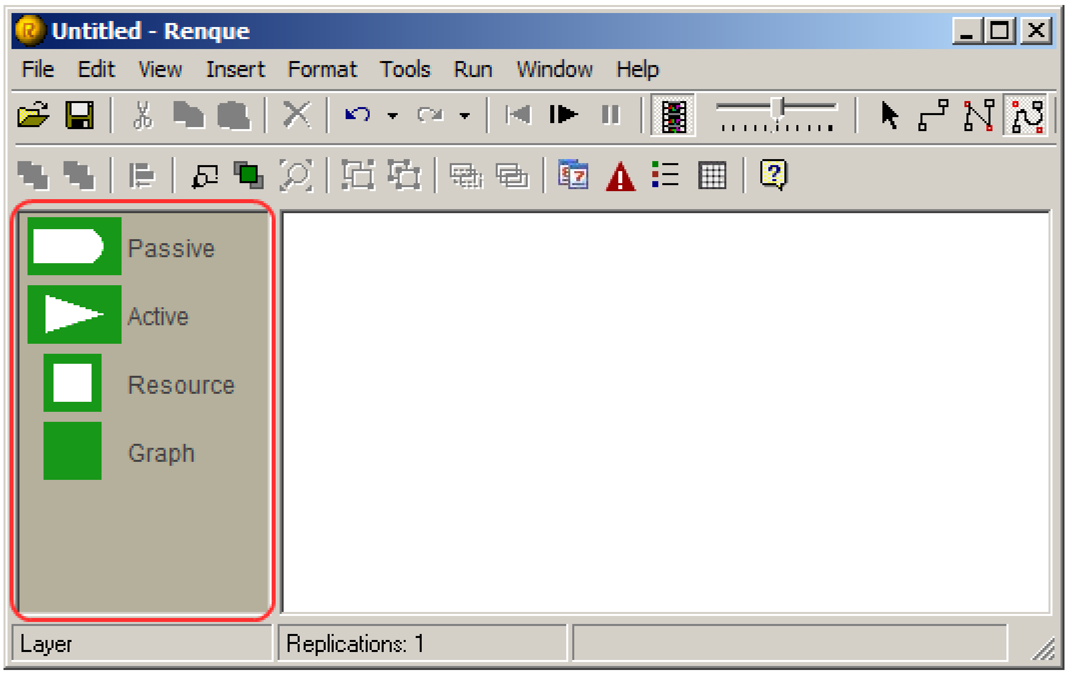
Upon a right click on the list, a pop-up menu is shown, which has the following commands:

• *New Layer*	Creates a new layer.
• *Select all*	Selects all layers.
• *Delete*	Deletes the selected layers.
• *Sort*	Sort the list alphabetically
• *Move*	Moves selected item in the list up or down.

While the layer tool is visible, the window's Menu bar & Toolbar are disabled, as are all other Renque windows. The Layer tool is deactivated by clicking on the Worksheet, or pressing the *Escape* key on the keyboard.

3.3 Toolbox

The Toolbox contains server templates. The Toolbox is used to add server objects to the Worksheet.



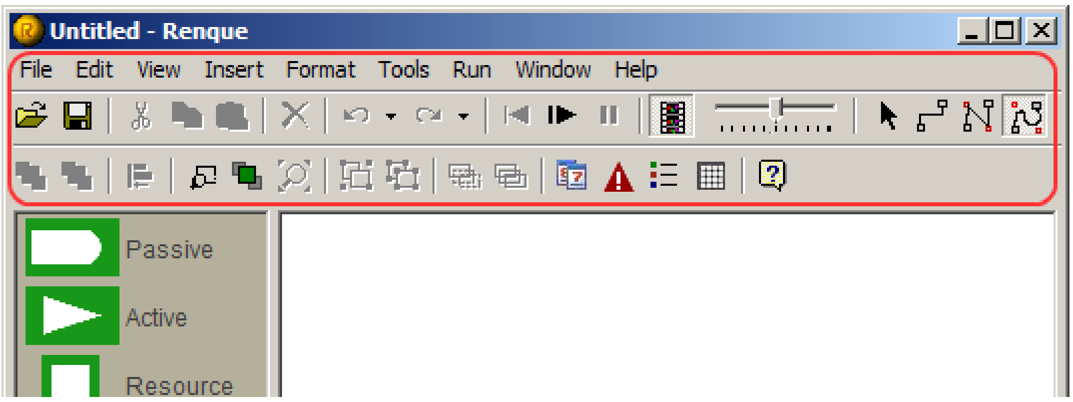
At start-up, the Toolbox contains the Active, Passive, Resource and Graph templates, which represent basic implementations of Renque server types. The Toolbox is user-configurable by adding and removing templates. User-defined templates are added to the Toolbox by selecting the **Add to Toolbox** command from the pop-up menu, which appears when a selected server object is clicked with the right mouse-button. A user-defined template inherits all properties from the source server, when created. When is server object is created from a template, all template properties are copied to the server. Templates properties cannot be changed.

Templates are removed by the **Remove** command in the pop-up menu of the Toolbox. The display order of templates in the Toolbox can be modified by the **Move** command in the pop-up menu. The **Restore defaults** command restores the original set of Toolbox templates.

The Toolbox may be hidden by checking the **Toolbox** item on the View menu. The Toolbox is not displayed if a Renque presentation file has been opened.

3.4 Menu bar & Toolbar

The Menu bar is found right underneath the title bar of the Main window. It has a range of commands grouped into drop-down menus, which are indicated by the words File, Edit, View.... The most frequently used Menu bar commands are also available as a button on the Toolbar.



The available Menu bar commands are listed below, together with the corresponding Toolbar button icon, if available, and a brief description of their function.

File menu

	New	Starts a new project and discards the current.
📂	Open project	Opens a project file.
💾	Save project	Saves the current project.
	Save project as	Saves the current project after prompting for a file name.
	Save presentation	Saves the current project as Renque Presentation file.
	Extract spreadsheet	Saves the Embedded worksheet of an opened project file as a separate file. Available only if the spreadsheet has failed to open in its application.
	Exit	Closes the application without saving.

Edit menu

	Undo	Undo the last mutation to the project. Clicking on the drop-down arrow opens a mutations list to select an item from.
	Redo	Redo the last undone mutation to the project. Clicking on the drop-down arrow opens a list of undone mutations to select an item from.
	Cut	Removes selected objects from the Worksheet and stores them in the Windows clipboard.
	Copy	Copy the selected objects the Worksheet to the Windows clipboard. Also available as pop-up command on the Worksheet.
	Paste	Paste objects from the Windows clipboard to the Worksheet. Also available as pop-up command on the Worksheet.
	Paste special	Paste from the Windows clipboard with options for the number of duplicates and the position of the pasted objects on the Worksheet.
	Delete	Delete objects selected in the Worksheet.
	Spreadsheet import	Import server, link and component objects from a keyword list in the Embedded worksheet.
	Find	Opens the Search utility to select servers by string comparison.
	Select	Selects specific object types in the Worksheet.
	Unselect	Unselects specific object types in the Worksheet.
	Preferences	Opens the Preferences utility to change preference settings of the application and the project.

View menu

	Presentation mode	Activates the presentation mode when checked, forcing the program to treat the current project as Renque Presentation.
	Runtime display	Toggles the Runtime display mode.
	Extend scale	Rescales the viewport to fit the entire model.
	Scrollbars	Determines when the Worksheet scrollbars are displayed. Selecting the Auto option displays the scrollbars only if the model does not fit into the viewport.
	Toolbox	Hides the Toolbox when unchecked.
	Toolbars	Hides a specific toolbar when unchecked.

Insert Menu

	Creative links	Adds a creating link to all selected servers on the Worksheet. Also available as pop-up command on the Worksheet.
	Destructive links	Adds a destructing link to all selected servers on the Worksheet. Also available as pop-up command on the Worksheet.

Format Menu

	Curve type: none	Disables link creation.
	Curve type: Orthogonal	Selects the orthogonal curve type for new links or curves being edited.
	Curve type: Polygon	Selects the polygon curve type for new links or curves being edited.
	Curve type: spline	Selects the spline curve type for new links or curves being edited.
	Modify curve	Switches to the Curve edit mode. Also available as pop-up command on the Worksheet.
	Resize	Switches to the Server resize mode. Also available as pop-up command on the Worksheet
	Bring to front	Places selected servers on top of the display order.
	Send to back	Places selected servers at the back of the display order.
	Group objects	Joins the selected objects in the Worksheet into a group, forcing subsequent joint selection of all group members.
	Ungroup objects	Breaks up all selected groups in the Worksheet.
	Fuse objects	Merges selected objects in the Worksheet into a Fusion server, represented by a single picture.
	Unfuse fusion servers	Breaks up a Fusion server into its constituents.
	Align	Opens the Alignment utility which allows organization of the alignment of selected server objects.

Tools menu

	Object properties	Opens the Object properties console, as will double-clicking the Worksheet.
	Simulation clock	Opens the Clock properties Window.
	Layers	Activates the Layer list.
	Runtime errors	Displays the Runtime error viewer.
	Event viewer	Displays the Event viewer window.
	Spreadsheet application	Opens or displays an Embedded spreadsheet.
	Data associations	Opens the Data associations manager.

	Presentation properties	Opens the Presentation properties console.
	Statistical analysis	Opens the Statistical analysis console.

Run menu

|◀	Reset	Resets the current simulation run, discarding all simulation data.
|▶	Restart	Starts a new simulation run, or restarts the current experiment.
❚❚	Pause	Pauses or resumes the current simulation replication.
🎞	Animation	Toggles animation on and off.
	End replication	Ends the current replication, preserving all replication data.
	Run experiment	Completes the simulation run of the current experiment, after which the Paused status is assumed. Only available if the simulation has multiple experiments.
	Reset experiment	Resets and discards all data of the current experiment. Not available for the first experiment in a simulation.
	Refresh	Repaints the Worksheet.

Window menu

	Set background	Changes the background color of the Worksheet.
	Arrange windows	Opens the Window arrangement utility.
	Fusion windows on top	Moves Fusion windows on top of other Renque windows.
	Graph windows on top	Moves Graph windows on top of other Renque windows.
	Open Fusion windows	Opens the Fusion window for all selected fusion servers on the Worksheet. Also available as pop-up command on the Worksheet.
	Close Fusion windows	Closes the Fusion window of all selected fusion servers on the Worksheet.
	windows list	Presents a list of all Fusion window titles. Clicking on a list item activates the corresponding window.

Help menu

	Getting started	Opens the Getting started section of the help document.
?	Renque help	Opens the help document.
	Renque website	Opens the Renque website in the default internet browser.
	Check for updates	Connects to the internet and checks if a more recent Renque release is available for download.

	About	Displays the application identifier panel. Click the panel to close it.

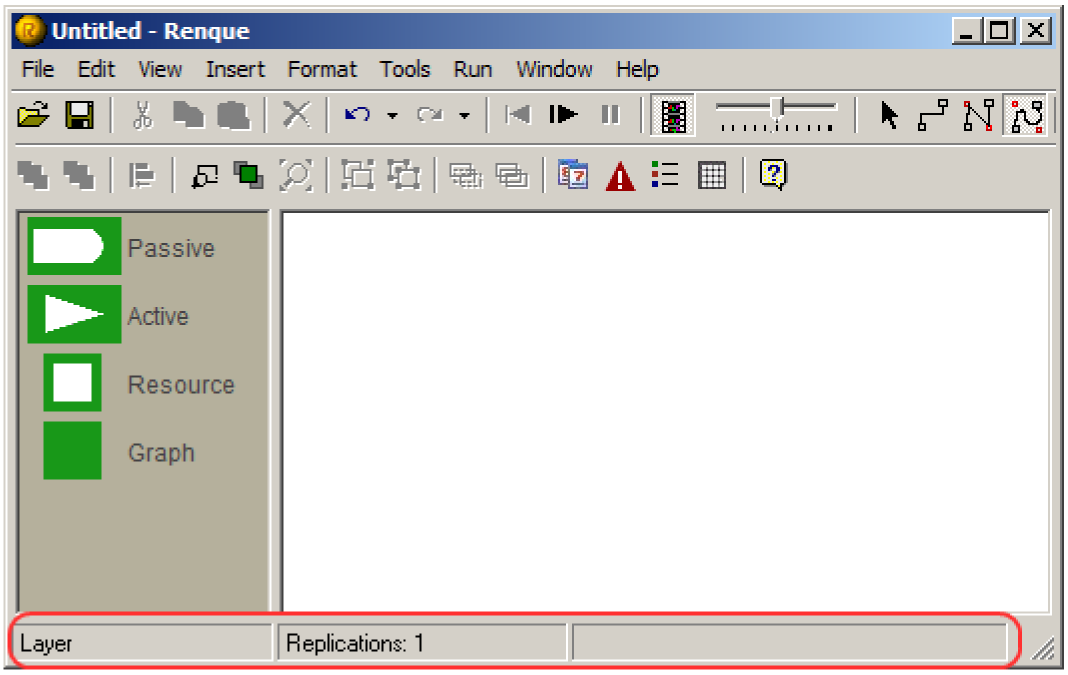
There are two items on the Toolbar that are not available on the Menu bar:

Animation speed slider
The Animation speed slider controls the animation speed. Moving the indicator to the right will speed-up the animation.

Zoom button
The Zoom button enables scaling of the viewport by a zoom factor specified by a mouse operation. If the button is pressed and the left mouse button is kept pressed while dragging the mouse over the Worksheet a rectangle is drawn of the same aspect ratio as the Worksheet, centered around the position where the mouse-button was pressed on the Worksheet. The size of the rectangle indicates the viewport scaling factor applied when the mouse button is released. The scaling direction depends on the direction of the mouse displacement. If the mouse was moved from left to right the viewport scale range is decreased to the rectangle area scale range. If the mouse button was moved to the left, the viewport is expanded to the range that results from shrinking the Worksheet area to fit the rectangle area. For a small mouse displacement, the viewport zoom factor remains unchanged and the center of the viewport is translated to the mouse location.

3.5 Status bar

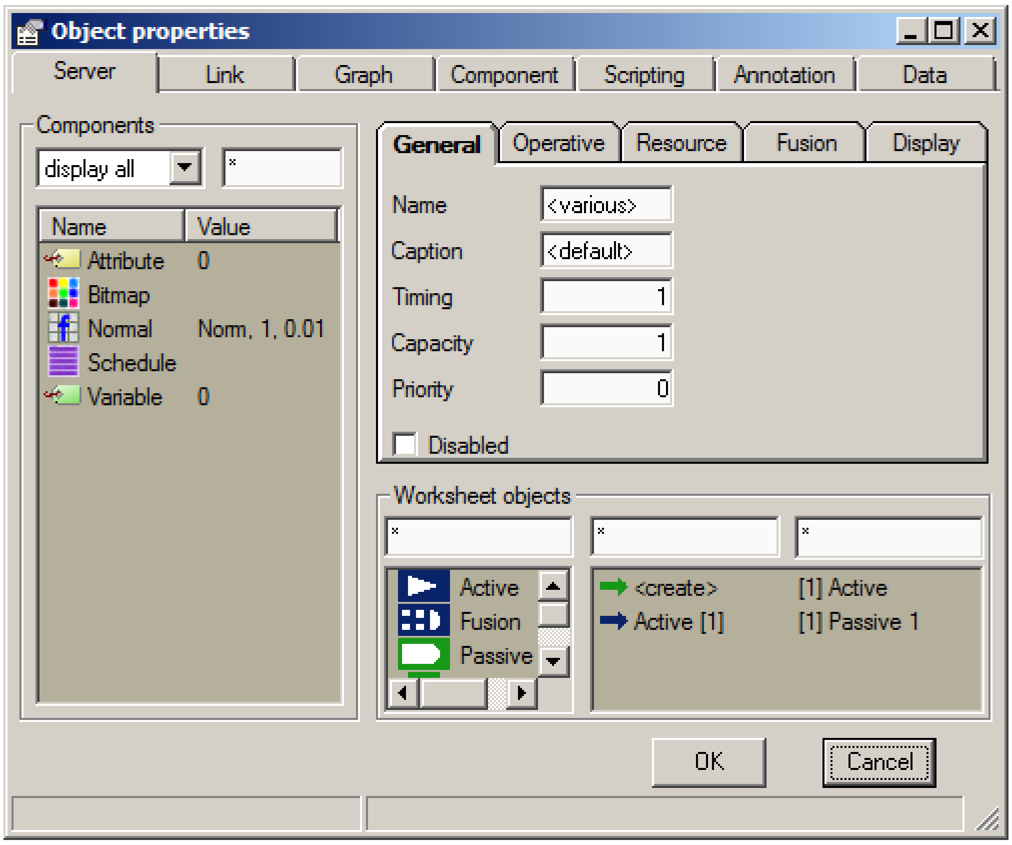
The Status bar is located at the bottom edge of the window and is divided into three panels. From left to right, panel 1 displays the current layer, panel 2 displays the simulation state and panel 3 displays the current time in the simulation in a user-specified format.



Clicking panel 1 activates the Layer list. Clicking panel 3 activates a text field that contains a format string for time display. The format string cay be modified to set the Time display format.

4 Object properties

The Object properties console provides access to properties of server and link objects on the Worksheet. The console also manages component objects of a Renque project, and simulation results are reviewed primarily on this console.



Name	Value
Attribute	0
Bitmap	
Normal	Norm, 1, 0.01
Schedule	
Variable	0

Name <various>
Caption <default>
Timing 1
Capacity 1
Priority 0
Disabled

Active
Fusion
Passive

<create> [1] Active
Active [1] [1] Passive 1

The controls on the window are organized in outlined frames, which provide access to different property categories of different object types. A tab strip located at the top of window determines which frames are displayed on the window.

This section has an introduction topic describing general operation of the console, a topic that deals with components, and topics for each item of the main tab strip:

- General operation
- Component management
- Server properties
- Link properties
- Graph properties
- Component properties
- Incident scripting
- Annotation
- Simulation data

4.1 General operation

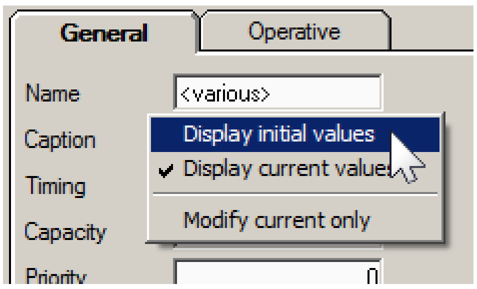
The Object properties console is opened by the **Object properties** command on the Tools menu or by double-clicking the Worksheet.

Context worksheet

The window can be opened from the Main window and from a Fusion window. The window from which the console is opened represents the context worksheet of the console. The console only displays properties of server and link objects that have the selected state in the context worksheet. If the selected objects do not have a uniform value for a specific property, the keyword <*various*> is displayed in text fields, check boxes are grayed out, and combo boxes are left empty. In general, control items on the console are disabled or hidden if there are no selected server objects that are affected by the controlled property. Alteration of object properties by the control items on the console is applied to all selected objects.

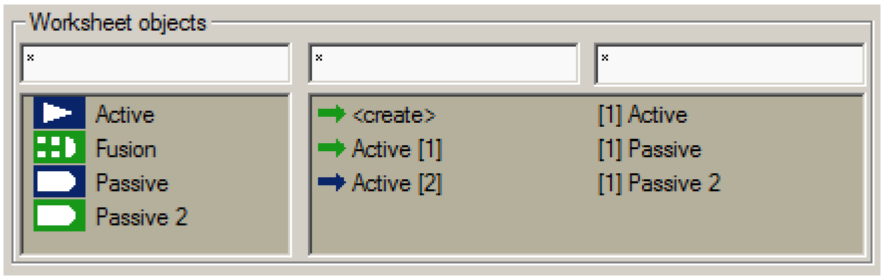
Simulation state context

Many object properties presented on the Object properties console can be changed by scripting during a simulation run. The simulation state context of the Object properties console determines whether the current value or the initial *Reset* status value is displayed for such properties. The control items that are affected by the Simulation state context are organized in frames, as indicated in the server, link and distribution property topics. The Simulation state context is set by a pop-up menu, which appears upon a right-button mouse click on these frames.



In the *Reset* status of a simulation, the control items on the pop-menu are all disabled and the **Display initial values** item is preselected. If the simulation is not in the *Reset* status, the **Display current values** item can be selected, which forces the display of property values in the current simulation state. By default, changes made on the console to a property are applied to both the initial an the current value of property. If the **Modify current only** option is checked, the initial value remains unchanged. Changes made to the model under application of the **Modify current only** option can not be undone in the Edit menu.

The **Worksheet objects frame**, located at the bottom of the console, catalogs the objects contained in the Context worksheet. The frame encloses the **Server browser** and either the **Link browser** or two **Routing list boxes**. The latter are shown if the Context worksheet has a single selected server and all selected links are connected to that server. Otherwise, the Link browser appears in the frame.



Server browser

By default, the server browser presents a list of the server objects contained in the Context worksheet. The servers are represented by their Name and Picture properties. The latter also indicates the selection status in the context worksheet. Servers in hidden layers are excluded from the list. The text field positioned above the browser may be used to specify a pattern matching string. Server objects are removed from the list if their Name property does match the pattern string.

The main purpose of the browser is to make it easier to assign server references to object properties. This is done by drag-dropped server objects in the browser onto other controls of the console, such as a text field or grid cell. You cannot create or delete servers in the browser, nor change the selected state of servers. Selection of a server in the browser does not give the object the selected state, as selection in the Worksheet does.

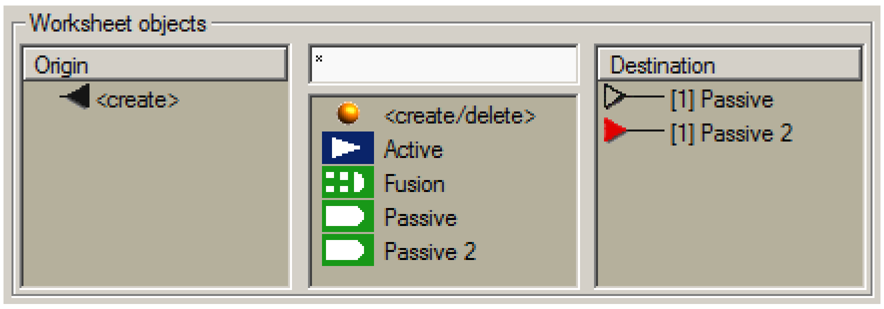
The browser has a pop-op menu which offers a number of display style options. If the **Sort alphabetically** menu item is checked, the servers are listed in alphabetical order, instead of the default Worksheet z-order sorted listing. Checking the **Show all** option includes servers which are not displayed on the Context worksheet because they are merged into Fusion servers. Such servers are displayed by the fusion path name, such as the label *Fusion1/Server1* for the server named *Server1*, which is fused into fusion *Fusion1*. Application of the **Hide fusion path** removes the fusion path again. The **Show all** and **Hide fusion path** options also affect the display of link objects in the below-mentioned Link browser.

Link browser

The link browser, which is found adjacent to the above-mentioned Server browser, presents a list of the link objects in the Context worksheet. The links are depicted by a standard icon, of which the color indicates the selection status of the link in the Context worksheet. The two columns of the browser display the name of respectively the origin server and the destination server, both accompanied by the index of the connection order to that server, enclosed in parentheses. The Link browser has the same function for links as the above-mentioned Server browser has for servers.

Routing list boxes

These items presents the Link objects connected to a uniquely selected server in the Context worksheet. The list box on the left-hand side displays the collecting links connected to the selected server, and the list box on the other side displays the connected dispatching links.



The routing list boxes can be used to create, delete and select links. Also, the link connection order can be changed and the origin or destination servers can be replaced by other servers. As for the above-mentioned Link browser, link items in the routing list boxes may be drag-dropped onto other controls on the console, in order to assign references to link objects. In contrast with the browser controls, selection of a link in the routing list does affect the selected state of the link object in the Context worksheet. Multiple link objects can be selected in either or both routing list boxes. When the console is closed, the original selection state is restored, unless the link was deleted.

The routing list boxes have either one or two columns. The first column displays a marker symbol that characterizes the link type and its properties, followed by the name of the origin or destination server. The meaning of the markers is given in the table below.

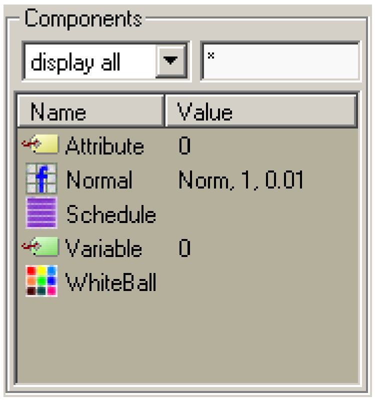
Marker	***Link type***	***Link properties***
▷—	Active origin server	
—◁	Active destination server	
D—	Passive origin with active destination	
———	Passive origin and passive destination	
—	Creating	
—	Destructing	
◣	Dispatching	Expiration, Overflow or Discard

End marker style	***Collection properties***	***Dispatch properties***
□	Default	default
■	Mandatory	Escort
□	Solitary	Independent
🟥	Mandatory and Solitary	Escort and Independent

If the Collect rule of the server has the value *Probability*, the upstream routing list displays the Collect weight of the links in a second column. The same applies for the downstream routing list for the Dispatch weight, if the Dispatch rule has the value *Probability*. The content of the routing list boxes is subject to the Simulation state context, A new link is created by dragging a server from the **Server browser** and dropping it on an empty area in the routing list box. The dragged server becomes the origin or destination server of the new link, depending on which of the list boxes is the drop target. Links are inserted in the list if the server is dropped on a marker icon in the first column. Alternatively, if the server is dropped on a server name, the origin or destination server is replaced by the dragged server. Creating- and destructing-type links are created using the **<create/delete>** item in the Server browser. The link connection order may be changed by the **Arrow buttons** at the bottom of the window. Links can be deleted using the **Delete key** or the **Delete item** command of the pop-up menu of the routing list boxes.

4.2 Component management

This frame encloses the Component repository, which presents a list of all component objects of the project.



Name	Value
Attribute	0
Normal	Norm, 1, 0.01
Schedule	
Variable	0
WhiteBall	

Component repository

The Component repository is used to create, delete, select and rename components. Just like the controls in the Worksheet objects frame, the repository can be used to assign an object reference to a property of another object by dragging a component from the repository and dropping onto another control item on the console.

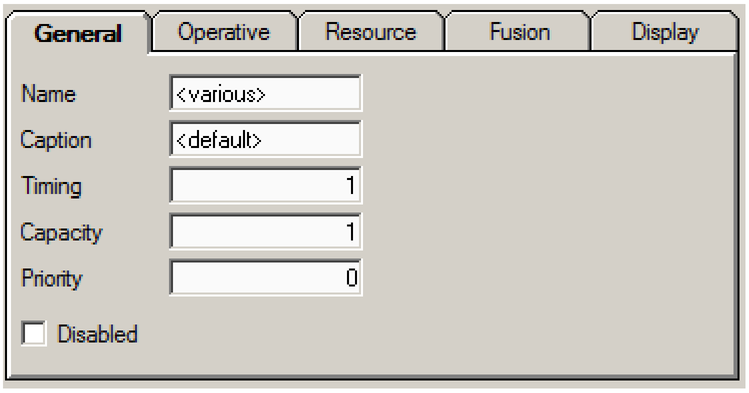
The repository has two columns. The **Name** column displays a type identifier icon followed by the component name. The **Value** column displays the default or primary value, if existing. The component listing style can be moderated using the combo box and the text field at the top of the frame. Selection of an item in the combo box restricts component display to the selected component type. Entering a pattern matching string in the text field removes all components from the list of which the Name property does match the pattern string.
.
New components are created with the **New component** command of the pop-up menu of the Component repository. This pop-up menu also has the usual items, **Copy**, **Paste and Delete item**, as well as the Paste special command, which allows for serial pasting of components from the Windows clipboard.

The component name is modified in the **Name** column and must be unique within the project. Variable and attribute component types can be defined as one-dimensional array. This is done by specifying dimensional bounds as argument to the name. The appropriate format is *ComponentName(lb to ub)*, where *lb* and *ub* represent the lower and upper dimensional bounds as integer numbers.

The properties of component objects are accessed by the Component tab on the Object properties console. Component properties as discussed in the Component properties topic.

4.3 Server properties

The Server tab on the Object properties console presents properties of selected Operative, Resource and Fusion server types. The Server tab displays the **Server type** tab strip when selected. This tab strip directs to additional tab pages, which present different property categories or specific properties of a server type. (The properties of Graph servers are accessed on the Graph tab on the console). A server type tab is hidden if no server of the corresponding type has been selected in the Context worksheet.



Name <various>
Caption <default>
Timing 1
Capacity 1
Priority 0
☐ Disabled

4.3.1 General server properties

The **General** tab presents properties shared by different server types.

Name

Internal server identifier string. The Name property may contain a maximum of 255 characters in the ranges A-Z, a-z, 0-9 and the underscore _ symbol. The name property must start with an alphabetic character and is case-insensitive. Server objects have an index property that appears in the object Name if unequal to zero, as a suffix number separated by a space character. The name part without the index number is referred to as the root name. The root name must be unique to servers.

Indexing of the selected servers is done automatically. If a string without suffix is entered in the text field, indexing of the selected servers starts from the highest index number of all existing non- selected servers with the same root name. If a suffix is specified in the text field, indexing starts with the specified suffix number. In both cases, server indices of non-selected servers with the same root name are skipped in the indexing procedure. All properties represented on the tab page are subject to the Simulation state context, except for the Name property.

Caption

Server title as displayed in the Worksheet in the Runtime display mode. The caption property can contain any character. The value <default> denotes that the Caption property is identical to the Name property.

Timing

Determines the storage time for entities in active servers and the maximum residence time and passive servers. Permitted values are real numbers >= 0 and all evaluating component types. The Timing property is set to *Void* if the Timing text field is left empty, which means that no timing is applied. In that case, no event is created in the Event calendar for entity removal, both for active and passive servers. The property is not available for resource and fusion servers.

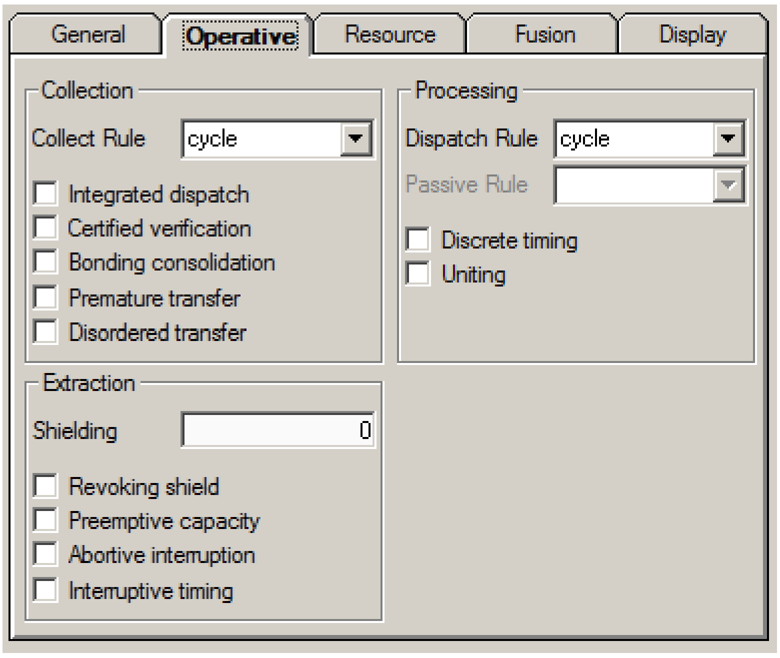
Capacity
Maximum number of residents allowed in a server. Permitted values are integer numbers >= 0 and the evaluating component types variable and distribution. The Capacity property is set to *Void* if the Capacity text field is left empty, which means that there is no capacity limitation. The Capacity property for Resource servers determines the capacity for resources instead of entities. The property is not available for fusion servers.

Priority
Determines the Priority value of calendar events generated by the server. Permitted values are integer numbers in the range -16000 to + 16000 and evaluating component of type variable and distribution. The property is not available for fusion servers.

Disabled
Disables the server. A Disabled active server does not perform any simulation actions and cannot store entities. Entities arriving at a Disabled passive server are not accepted and are stored in the link buffer instead. Resource servers will not allocate any resources when disabled. The property is accessed by scripting through the `Enabled` scripting procedure. The property is not available for fusion servers.

4.3.2 Operative server properties

The **Operative** tab presents properties of Operative servers. The properties on this tab page determine the way active and passive servers operate in a simulation model. All properties represented on the tab page are subject to the Simulation state context.



Collect Rule: cycle
- [ ] Integrated dispatch
- [ ] Certified verification
- [ ] Bonding consolidation
- [ ] Premature transfer
- [ ] Disordered transfer

Dispatch Rule: cycle
Passive Rule:
- [ ] Discrete timing
- [ ] Uniting

Shielding: 0
- [ ] Revoking shield
- [ ] Preemptive capacity
- [ ] Abortive interruption
- [ ] Interruptive timing

The frame labeled *Collection* presents server properties associated with collection of entities in the operating mechanism of active servers.

Collect Rule
Determines the method by which a non-Mandatory link is selected in the verification stage of the operating procedure of an active server. Possible values: *Cycle* (test links in top-down order, starting from the link selected previously); *Random* (random

choice); *Probability* (weighted random choice dependent of the Collect Weight property of the links); *Order* (test links in order, starting from the first link). The evaluating component types variable and distribution can be assigned to the Collect Rule property. In that case a link is selected by property evaluation of the assigned component.

Integrated dispatch
Determines the actuation method of the collection procedure of active servers. By default, a new collection procedure is started when the transfer stage of the previous collection procedure is completed. If this property is applied, a new collection procedure is not started until all entities collected by the previous collection procedure have been dispatched.

Certified verification
Enables entity availability confirmation for incitation of the verification stage of the collection procedure. By default, upon successful completion of incited verification, entity collection moves forward to the transfer stage without confirmation of the availability of the entities to be collected. If this property is applied, entity availability is rechecked when a incited verification procedure is completed.

Bonding consolidation
Protects the collection procedure of active servers in the consolidation stage against entity displacement. If this option is applied, entity bonding is performed on entities consolidated by the server. If a bonded entity is displaced, it is either sent to the bonding server or causes the bonding server to be interrupted.

Premature transfer
Enables entity transfer in the collection procedure of active servers prior to completion of the consolidation stage. By default, transfer of entities is postponed until all entities to be collected are available for transfer. If this property is applied, the availability test is omitted and all available collected entities are transferred upon consolidation.

Disordered transfer
Determines the order by which entities are transferred in the collection procedure of active servers. By default, active servers transfer all entities to be collected for each collecting link consecutively, in top-down order. Application of this property results into transfer of entities in order of availability.

The frame labeled *Processing* presents server properties associated with storage in and release of entities from servers.

Dispatch Rule
Determines the selection method of a non-Escort link in the dispatch routine of an active server, and for incitation by a passive server. Possible values: *Cycle* (test links in order, starting from the link selected previously); *Random* (random choice); *Probability* (weighted random choice dependent of the Dispatch Weight property of the link); *Order* (test links in order, starting from the first link). All evaluating components types can be assigned to the Dispatch Rule property. In that case a link is selected by property evaluation of the assigned component.

Passive Rule
Determines the sequence by which resident entities are retrieved from a passive server in the collection procedure an active server. Possible values are *FIFO* (first-in-first-out), *LIFO* (last-in-first-out) and *Random* (random choice from then resident entities). Evaluating components of type variable and distribution can be assigned to the Passive Rule property. In that case an entity is selected by property evaluation of the assigned component.

Discrete timing
Forces individual evaluation of the Timing property for entities stored in an active server during transfer. By default, all entities stored during the collection procedure of an active server are assigned a uniform Timing value. If this property is applied, the Timing property is evaluated and applied for each individual entity stored in the server.

Uniting
Forces merging of transferred entities. If applied, all entities collected by the collection procedure of an active server are united into a single target entity. The target entity is the first entity stored in the server. By default, the remainder of the transferred entities are simply deleted, but their transfer does cause a Unite incident, which permits customization of the uniting process by scripting. The Timing property of the server is applied to the target entity after all collected entities have been united. Note that link objects also have a Uniting property.

The frame labeled *Extraction* presents server properties associated with entity displacement.

Shielding
Determines resistance against `Interrupt` and `Retract` scripting calls. Permitted values are integer numbers in the range -16000 to +16000 and evaluating components of type variable and distribution. The *Level* argument passed with the `Interrupt` or `Retract` scripting statements is tested against the value of the Shielding property. If the *Level* argument value is smaller than Shielding value, the `Interrupt` call is overruled, and the result of the `Retract` call depends on the below-mentioned Revoking property of the server.

Revoking shield
Determines the effect of a `Retract` scripting statement call, which is overruled by the above-mentioned Shielding property. By default, the statement call is deferred and retraction will be reattempted every time the entity is stored in a server. The statement call is cancelled if this property is applied.

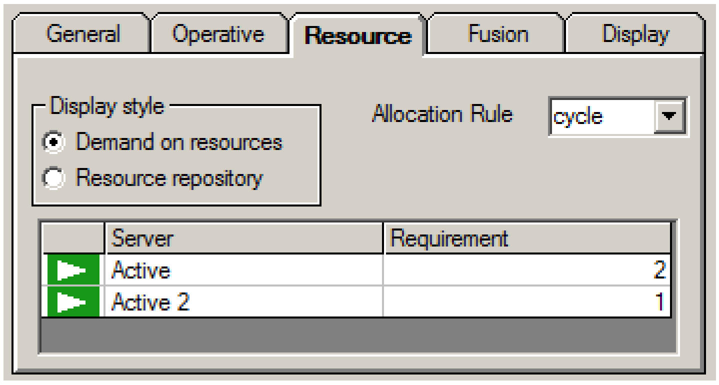
Preemptive capacity
Determines the response to a Capacity deficiency of a server. By default, a decrease of the Capacity value of a server is ignored, and the number of residents is allowed to surpass the Capacity value. An Overflow incident occurs if this property is applied and the Capacity value becomes smaller then the number of residents.

Abortive interruption
Determines the effect of interruption on the collection procedure of active servers. By default, interruption of an active server only causes adaptations in the collection procedure of the server. If this option is applied, interruption aborts and restarts the collection procedure of the server.

Interruptive timing
Causes a server interruption in response to a change of the Timing property during a simulation. The Timing property can be altered by the `Timing` scripting command, by cell content changes of a Property association, or manually in the *Current value* Simulation state context on the console.

4.3.3 Resource properties

The **Resource** tab presents properties of Resource servers. The control items on this tab page determine the number of resources to be allocated to active servers, and the allocation method applied. Only the Requirement and Allocation Rule properties on this tab are subject to the Simulation state context.



Display style
(● Demand on resources) ○ Resource repository

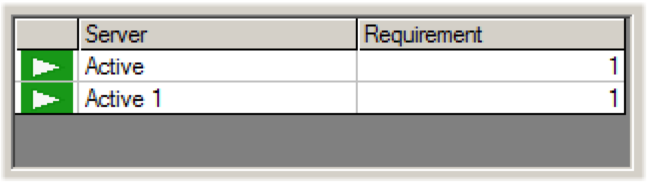
Allocation Rule: cycle

	Server	Requirement
▶	Active	2
▶	Active 2	1

The frame labeled *Display style* contains two option buttons, which determine the way resource allocation requirements are presented in the area underneath the frame. Selecting the **Server requirements** button displays the Resource repository. Selecting the **Demand on resources** button displays the below-mentioned Resource demand grid instead.

Resource demand grid

The Resource demand grid shows the Allocation requirement properties of the Resource servers with the selected state in the Context worksheet. The grid rows represent positions in the allocation preference order. The name of the active server of the allocation preference position is displayed in the **Server** column. The Allocation requirement property of the allocation preference positions is shown in the **Requirement** column. The keyword <*various*> is displayed if the selected resource servers do not have uniform properties for a grid cell. If one of the selected resource servers does not have an active server assignment for a particular position in the allocation preference order, the keyword <*incomplete*> is displayed in the corresponding cell of the **Server** column.

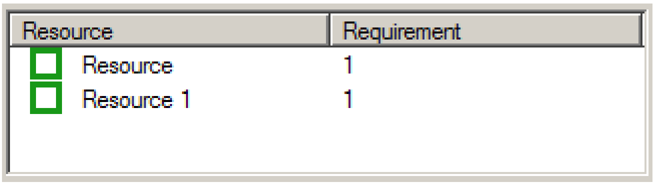


	Server	Requirement
▶	Active	1
▶	Active 1	1

Active servers are added to the grid by dragging a server object from the Server browser and dropping it onto on the empty area in the grid. If the item is dropped on the server picture of an existing row, a preference position is inserted before the target grid row. If the item is dropped on a grid cell in the **Server** column, the Server object of the drop row is replaced. The Allocation requirement value can be changed by typing a new value into a cell of the **Requirement** column. Permitted values are integer numbers ≥ 0 and the evaluating component types variable and distribution. Grid rows may be deleted using the **Delete item** command in the pop-up menu of the list. The grid row order may be changed by the **arrow buttons** at the bottom of the console.

Resource repository

This list presents all resource servers in visible layers of the project, sorted by z-order. The column labeled **Requirement** denotes the Allocation requirement property of the active servers with the selected state in the Context worksheet for the Resource servers in the list. The keyword <*incomplete*> in the **Requirement column** indicates one of the selected active servers does not have an allocation requirement for the corresponding resource server. The keyword <*various*> indicates that all selected active servers have an assigned allocation requirement, but with different values (which may include the value 0). The keyword <*none*> indicates that none of the selected active servers have an assigned allocation requirement.



Resource	Requirement
Resource	1
Resource 1	1

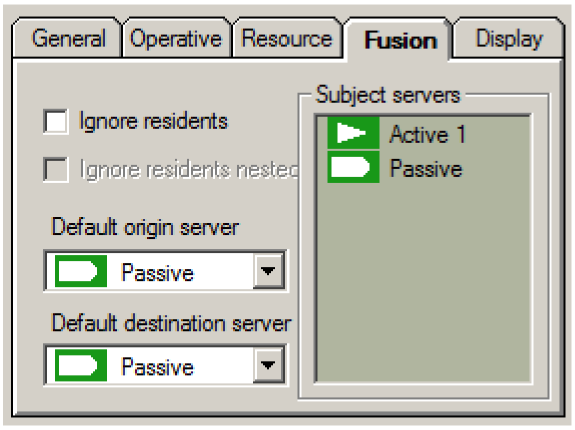
The Allocation requirement property can be changed in the same manner as for the above-mentioned Resource demand grid

Allocation Rule

Determines the selection method by which a resource server seeks active servers in the Allocation preference order for incitation. Possible values: *Cycle* (test servers in order, starting from the server last served); *Random* (random choice); *Order* (test servers in order, starting from the top). Evaluating components of the types variable and distribution can also be assigned to the Allocation Rule property. In that case servers are selected on the basis of position in the Allocation preference order by property evaluation of the assigned component.

4.3.4 Fusion properties

The **Fusion** tab presents properties of Fusion servers. The controls on this tab determine the link connectivity of fusion servers and some options for data recording.



Fusion member browser

This browser is available only if a single fusion server has been selected. The browser displays the server objects merged into the selected fusion. The browser can be used to get a quick view of the fusion composition and to assign servers to the Default origin server and Default destination server properties by drag-drop operations.

Ignore residents

Disables resident entity bookkeeping for fusions. The resident entities of a fusion server include all resident entities of the server and link objects merged into the fusion, as well as entities traveling on merged links. The fusion residents are registered by default. If this option is applied, resident registering is omitted, which disables resident Animation and Data recording for the fusion.

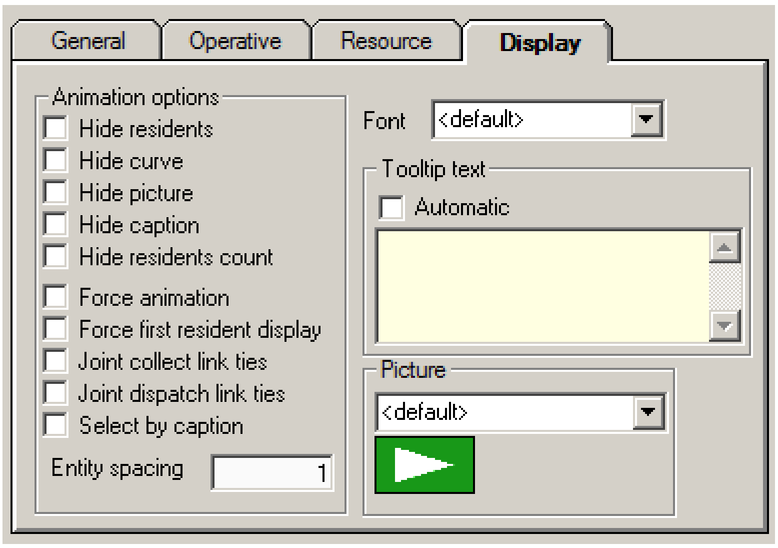
Ignore residents nested
Disables resident entity bookkeeping for nested fusions, as the above-mentioned Ignore residents item does for the selected Fusion servers. Clicking this option disables resident entity bookkeeping for all fusions nested in the fusions represented on the tab. The control is disabled if none of the selected fusion servers have nested fusions, and grayed out if the nested fusions have a non-uniform value for the Ignore residents property.

Default origin server
This combo box selects a fused server object to act as origin server for links created with the Fusion server as origin, on the Worksheet that contains the Fusion server. Available only if a single fusion server is selected on the Context worksheet.

Default destination server
This combo box selects a fused server object to act as destination server for links created with the Fusion server as origin, on the Worksheet that contains the Fusion server. Available only if a single fusion server is selected on the Context worksheet.

4.3.5 Display properties

The **Display** tab presents properties of all logical server types. The control items on this tab page determine how the servers are displayed and animated on the Worksheet. Only the Picture property on this tab page is subject to the Simulation state context.



Hide residents; curve; picture; caption; residents count
Hides the indicated items if the Runtime display mode is effective.

Force animation
Pauses animation after and an entity is stored in the server and removed at the same simulation time, while no zero-duration travels are animated on the Worksheet. Application of this option ensures that stored resident entities are visible in animation for at least the Zero timing Travel animation time. This property is ineffective if the above mentioned Hide residents option is applied

Force first resident display
By default resident icons are displayed on the server curve only if the icon fits completely on the curve. If applied, the first resident icon is displayed even if it doesn't fit on the curve.

Joint collecting link ties; dispatching link ties

By default the curve connections are spread in vertical direction across the connecting edge of the server picture. If the property is applied, the curves of connected links are anchored to the server picture on a single location at the center of the connecting edge.

Select by caption

By default selection of servers is possible only through the picture and resident curve. If applied, servers can be selected also by the caption text region, provided the caption is visible.

Entity spacing

Determines the display spacing of entities on the resident curves in animation. A spacing factor is specified in the associated text field, which accepts any positive number. For the default value 1 the distance between two entities is equal to half of the sum of the maximum of the height and width of both entity icons. The entity distance changes proportionally with the specified spacing factor value.

Font

the Font combo box sets the font style and size for display of the server on the Worksheet. Clicking the drop-down arrow opens the Font selection utility, by which font properties can be assigned in a prearranged manner.

Tooltips

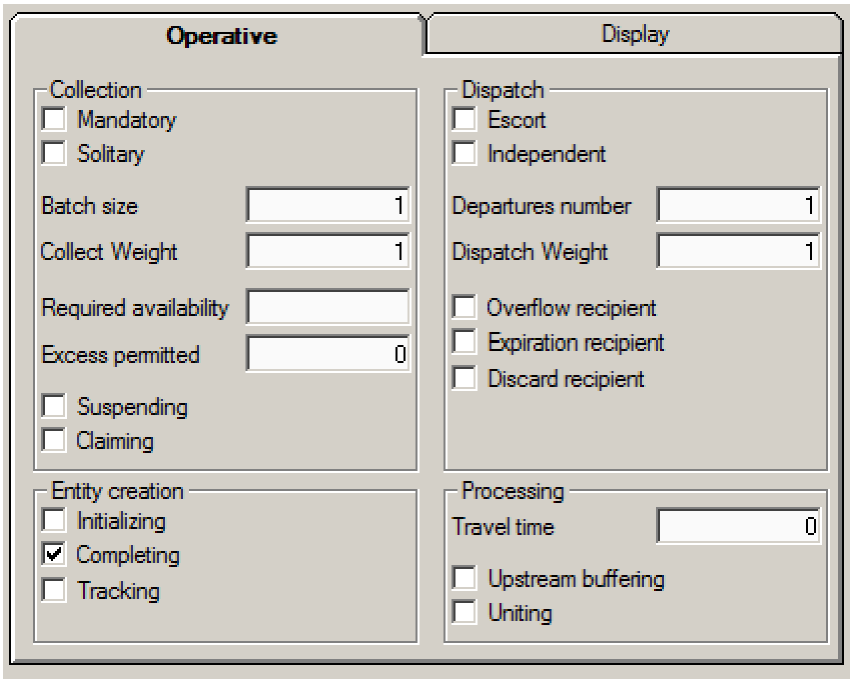
The frame labeled *Tooltip text* contains a text field which specifies a text string, which appears as Windows Tooltip if the mouse hovers over a visible server picture in the Worksheet. If the **Automatic** box is checked, the text field is disabled, and a listing of properties with non-default values is applied as tooltip for the object.

Picture

Sets the picture component of the selected servers. Type the name of the desired item or select it from the combo box to change. The Picture preview box displays the assigned picture component at a size corresponding to the default picture size. The picture is displayed only if all selected servers have an identical picture property. The picture property of the selected servers may be set by dragging a picture component from the Component repository into the Picture preview box.

4.4 Link properties

The **Link** tab on the Object properties console presents properties of selected Link objects. The Link tab page displays the **Server type** tab strip when selected. This tab strip directs to additional tab pages, which present different property categories.


Operative | Display

Collection
- [ ] Mandatory
- [ ] Solitary

Batch size	1
Collect Weight	1
Required availability	
Excess permitted	0

- [ ] Suspending
- [ ] Claiming

Entity creation
- [ ] Initializing
- [✓] Completing
- [ ] Tracking

Dispatch
- [ ] Escort
- [ ] Independent

Departures number	1
Dispatch Weight	1

- [ ] Overflow recipient
- [ ] Expiration recipient
- [ ] Discard recipient

Processing

Travel time	0

- [ ] Upstream buffering
- [ ] Uniting

4.4.1 Operative link properties

The frame labeled *Collection* presents link properties associated with collection of entities on the link in the operating mechanism of active servers.

Mandatory

Determines the role of the link in the verification stage of the collection procedure of an active destination server. If this option is applied, the link is excluded from the link selection procedure governed by the Collect rule of the destination server.

Solitary

Excludes links from collection in the verification stage of the collection procedure of active destination servers. If applied to a Mandatory link, the link is excluded from the collection procedure. If applied to the selected non-Mandatory link in the collection procedure, all Mandatory links are excluded from the collection procedure.

Batch size

Minimum number of entities to be collected on the link in the collection procedure of an active destination server. Permitted values are integer numbers >= 0 and the evaluating component types variable and distribution.

Collect Weight

Probability weight factor for the non-Mandatory link selection procedure, as governed by the Collect Rule value *Probability*. The default value is 1. Permitted values are floating point numbers >= 0. Evaluating components of type variable and distribution can also be assigned to the Collect Weight property.

Required availability
Number of entities available for collection on the link required to pass the verification stage of the collection procedure of an active destination server. Permitted values are any integer number, the *Void* value, and components of type variable and distribution. By default, the property is *Void* and the text field is left empty. The *Void* value signifies that the number of entities required is equal to the Batch property. A zero value signifies that no entities are required, and a value smaller than zero signifies the number of entities allowed short of the Batch property. Evaluating components of type variable and distribution can also be assigned to the Required property.

Excess permitted
Denotes the maximum number of surplus entities collected on the link in the consolidation stage of the collection procedure of an active destination server. If more entities are available for collection on a link than it's Batch value, this property determines the number of entities collected in excess of the Batch size. Possible values for this property are integer numbers and *Void*. If the text field is left empty the property is *Void*, signifying that the number of excess entities collected is equal to the available number of excess entities. The default zero value signifies that no excess entities are collected, and a value smaller than zero signifies the number of excess entities omitted from the entities available in excess of the Batch property. Evaluating components of type variable and distribution can be assigned to this property.

Suspending
Postpones retrieval of entities from passive servers in the consolidation stage of the collection procedure of an active destination server.

Claiming
Prevents entities consolidated by an active server from collection by another server. If applied, consolidated entities are claimed if they are stored in the passive origin server or in the buffer of a link to which the above-mentioned Suspending property is applied. Claimed entities can also be bonded by the collecting server.

The frame labeled *Dispatch* presents link properties associated with the dispatch routine of active origin servers of the link or with the reception of displaced entities.

Escort
Determines the role of the link in the dispatch routine of an active origin server. If applied, the link is excluded from the link selection procedure governed by the Dispatch rule of the origin server. In the dispatch routine, the dispatch entity is sent to the selected non-Escort dispatching link, and copies of the dispatch entity are sent to Escort links.

Independent
Excludes links from the dispatch routine. if applied to an Escort link, the link is excluded from the dispatch routine. If applied to the selected non-Escort link, all Escort links are excluded from the dispatch routine.

Departures number
Number of entities sent to a dispatching link in the dispatch routine. Permitted values are integer numbers >= 0 and all evaluating component types. A zero value for the selected non-Escort link causes the dispatch entity to be deleted, the default value 1 dispatches only the dispatch entity, and for higher values also copies of the dispatch entity are sent. For Escort links, the Departures property signifies the number of copies of the dispatch entity sent to the link.

Dispatch Weight

Probability weight factor for the non-Escort link selection procedure, as governed by the server Dispatch rule value *Probability*. Permitted values are floating-point number >= 0 and all evaluating component types.

Overflow recipient

Assigns a link as recipient for entities displaced from a server, causing an Overflow incident. Only one Overflow dispatching link of a server can be designated Overflow recipient. When this property is applied to a link, it is removed from all other dispatching links of the origin server.

Expiration recipient

Assigns a link as recipient for entities displaced from a server, causing an Expiration incident. Only one dispatching link of a server may be designated Expiration recipient. When this property is applied to a link, it is removed from all other dispatching links of the origin server.

Discard recipient

Assigns a link as recipient for entities displaced from a server, causing a Discard incident. Only one dispatching link of a server may be designated Discard recipient. When this property is applied to a link, it is removed from all other dispatching links of the origin server.

The frame labeled *Entity creation* presents properties of creating links.

Initializing

Enables entity creation on a creating link at the start of a simulation replication. If applied, a number of entities equal to the Batch property of the link are created at the replication start and sent to the destination server. Upon arrival at the destination server, the entities are stored in the server. Recorded statistics of the link and of the destination server are reset when all initializing entities have been stored in the destination server. For an active destination server, the Initializing entities are subsequently dispatched without delay. The Initializing property has no function for non-creating links.

Completing

Enables entity creation on a creating link in response to requests by upstream connected active servers. This property has distinctive functionalities for links with active and passive destination servers. For an active destination server the property forces the link to create entities requested in the consolidation stage of the collection procedure of the server. For a passive destination server the link produces as many entities as requested by an active destination server of a dispatching link of the passive destination server of the Completing link and not available as resident in the passive server. A Batch size value of the Completing link greater than unity generates surplus entities. Only one Completing collecting link can be assigned to a passive server. When applied to a link, the Completing property is removed from the other Completing collecting links of the destination server. The property has no function for non-creating links.

Tracking

Enables entity retraction on a creating link. If applied, the location of entities created on the link is recorded during a simulation. This information is used by the retraction routine to extract entities from their current location.

The frame labeled *Processing* presents link properties associated with entity travel and buffering on links.

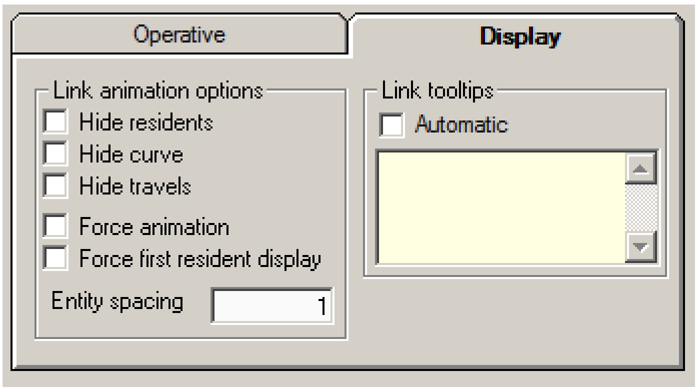
Travel time
Duration of the entity travel period on the link. Permitted values are floating-point numbers >= 0 and all evaluating component types.

Upstream buffering
Determines the buffer location on a link. By default, the link buffer is located on the downstream side of the link, and entities are stored after traveling on the link. If this property is applied, entities are buffered at the upstream side, before traveling.

Uniting
Forces merging of consolidated entities. If applied, all entities consolidated on the link by the collection procedure of an active destination server are united into a single unite entity. The unite entity is the first entity stored in the link buffer by the collection procedure. By default, the remainder of the consolidated entities are simply deleted, but do cause a Unite incident, which permits customization of the uniting process. Note that active servers also have a Uniting property.

4.4.2 Display properties

The control items on The **Display** tab page determine how the links are displayed and animated on the Worksheet.



Hide residents; curve; travels
Hides the indicated items if the Runtime display mode is effective.

Force animation
Pauses animation after an entity is stored in the link buffer and removed at the same simulation time, while no zero-duration travels are animated on the Worksheet. Application of this option ensures that stored buffer entities are visible in animation for at least the Zero timing Travel animation time. This property is ineffective if the above mentioned **Hide residents** option is applied

Force first resident display
By default resident icons are displayed on the link curve only if the icon fits completely on the curve. If this property is applied, the first resident icon is displayed even if it doesn't fit on the curve.

Entity spacing
Determines the display spacing of entities on the link curve in animation. A spacing factor is specified in the associated text field, which accepts any positive number. For the default value 1 the distance between two entities is equal to half of the sum of the

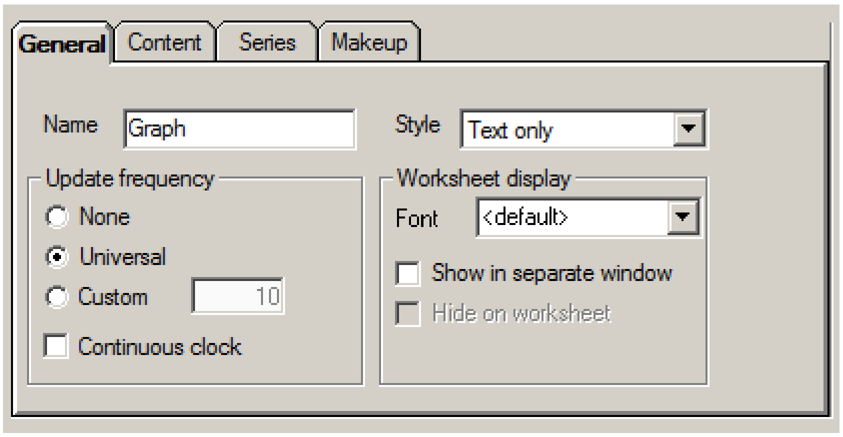
maximum of the height and width of both entity icons. The entity distance changes proportionally with the specified spacing factor value.

Tooltips

The frame labeled *Link tooltips* contains a text field which specifies a text string, which appears as Windows Tooltip if the mouse hovers over a visible link curve in the Worksheet. If the **Automatic** box is checked, the text field is disabled, and a listing of properties with non-default values is applied as tooltip for the object.

4.5 Graph properties

The **Graph** tab on the Object properties console presents properties of the selected Graph servers. (The properties of other server types are accessed on the Server tab.) At the top of the Graph tab page another tab strip is shown, which directs to additional tab pages for graph servers. These tabs manage graph server properties in different categories.



Name: Graph
Style: Text only
Update frequency
( ) None
(●) Universal
( ) Custom 10
[ ] Continuous clock
Worksheet display
Font: <default>
[ ] Show in separate window
[ ] Hide on worksheet

4.5.1 General graph properties

The **General** tab page manages the common graph server properties, which apply to all graph server types.

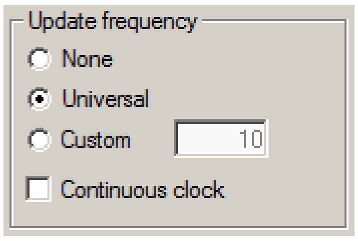
Name
Name of the graph server.

Style
This combo box determines the primary display style of the graph server. The default value *Text* is used to display text on the server. The displayed text is set on the Content tab, and may include literal strings, simulation data and simulation clock information. In addition, there are five alternative styles, which are used to display different kinds of charts on the server:

• *Time-series line chart*	Data plot as a function of time.
• *Frequency histogram*	Histogram of frequency intervals of property value observations.
• *Column chart*	Column chart of current property values.
• *Replications histogram*	Histogram of frequency intervals of final parameter values for replications. This graph style requires enabled statistics recording for the Series objects of the server.
• *Confidence diagram*	Column diagram for confidence intervals of data parameters, analogous to the statistical data listings of the Statistical analysis tool. This graph style requires multiple replications and enabled statistics recording for the Series objects of the server.

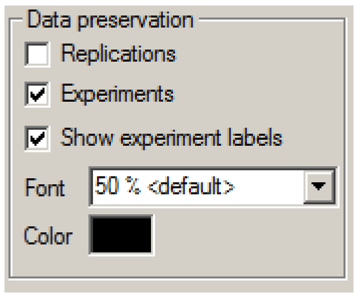
Update frequency
The frame labeled *Update frequency* manages the update frequency of the graph server during a simulation run. Data are supplied to the graph every time the displayed parameter value changes in the simulation state of the project. New chart

data are not necessarily displayed immediately on the server. Data can be stored in a buffer in order to save on computing resources, until the graph server is updated.


Update frequency
- ( ) None
- (●) Universal
- ( ) Custom 10
- ☐ Continuous clock

• *None*	If this option is selected, graph servers are updated only when a simulation run is paused or stopped.
• *Collective*	Periodic updates, as defined by the **Collective update** item of the Runtime preferences.
• *Custom*	Applies a specific update frequency defined for the object. The update interval time is specified in seconds real time in the associated text field, which accepts any positive non-zero number.
• *Continuous clock*	Updates the server whenever the simulation time changes. Only available for the *Text* graph Style. Only effective if the Content text property of the server has a placeholder string that represents a time function.

The frame labeled *Data preservation* controls the retention of replication and experiment data for charts, and the display of labels to identify plotted curves for different experiments. The frame is not shown for the Style value *Text*.


Data preservation
- ☐ Replications
- ☑ Experiments
- ☑ Show experiment labels

Font 50 % <default>

Color ■

Replications

By default, chart data are cleared when a new replication starts. If this option box is checked, chart data are retained for all simulation replications, and displayed as separate lines or columns. This option is not available for the Style values *Replications histogram* and *Confidence diagram*.

Experiments

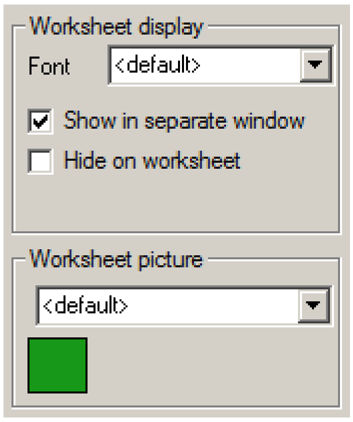
By default, chart data are cleared when a new experiment starts. If this option box is checked, chart data are shown for all simulation experiments as separate lines or columns. If the above-mentioned replications item is also checked chart data are preserved for all replications of all experiments. Otherwise only the last replication of an experiment is preserved in the chart. The option is available only if the number of simulation experiments has been set to a value greater than 1.

Experiment labels
Enables the display of labels *Time-series line charts*. Experiment labels indicate the experiment number for the chart lines. Available only if the above mentioned **Experiments** option box is checked.

Font
Assigns a font style to experiment labels. Available only if the above mentioned **Experiments** option box is checked.

Color
Assigns a font color to experiment labels. Available only if the above mentioned **Experiments** option box is checked.

The frame labeled *Worksheet display* determines the display properties for the Graph server on the worksheet.



Worksheet display

Font <default>

[✓] Show in separate window

[ ] Hide on worksheet

Worksheet picture

<default>

🟩

Font
Assigns a font style to the server name for display on the worksheet.

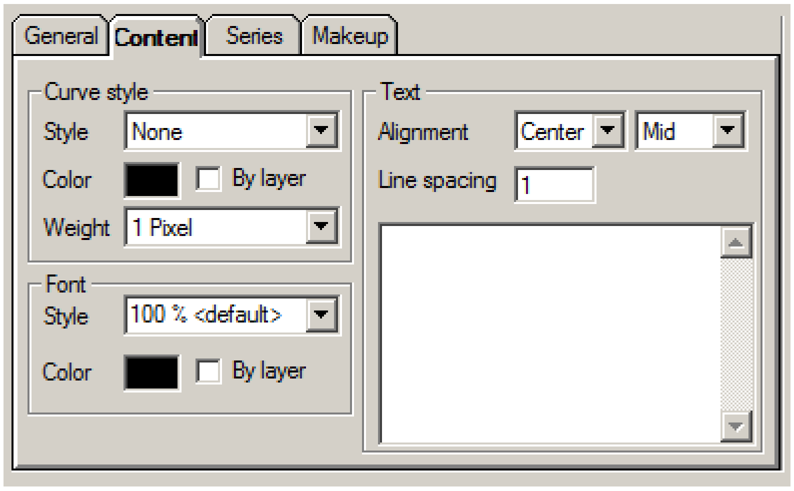
Show in separate window
By default, a graph server is displayed on the worksheet. If this option is checked, the graph server is displayed in its own separate window, while on the worksheet the server is represented only by the label and picture property. Double clicking the graph window opens the Object properties console, just as double clicking the server in the worksheet. If opened form a graph window, the graph window server is the sole server with the selected state in the Context worksheet.

Hide on worksheet
Hides the server on the worksheet if the above-mentioned **Show in separate window** option is applied.

Worksheet picture
Assigns a Picture component to the server for display on the worksheet. Only available if the Show in separate window option is applied

4.5.2 Content

The Content tab page manages the content of Graph servers with the value *Text* of the Style property. This tab page determines which text is displayed, as well as the display style for the text. It also controls the display style of an adjustable curve on the server.



Curve style
Style: None
Color: ■ ☐ By layer
Weight: 1 Pixel

Font
Style: 100 % <default>
Color: ■ ☐ By layer

Text
Alignment: Center, Mid
Line spacing: 1

Curve style
The frame labeled *Curve style* manages the display method of a curve in the graph server. The upper combo box selects the **line style,** from the options *None*, *Solid* and a number of patterns. Clicking the **color select box** will opens the standard color selection utility of the Windows operating system, to set the line color. The **By layer** check box selects the color of the Worksheet layer of the server as curve color. The lower combo box sets the **line weight** in pixels. Line style settings other than *None* are displayed as *Solid,* if a line weight value greater than 1 pixel is selected. The curve itself is edited on the Worksheet as for the residents curve of other server types.

Font
The frame labeled *Font* manages the font style, size and color of the content text displayed on the graph server. Clicking the drop-down arrow of the **Font style** combo opens the Font selection utility, by which font properties can be assigned in a prearranged manner. The font color is set by the **Color selection** box. The **By layer** check box selects the color of the Worksheet layer of the server as font color.

Content text
The frame labeled *Text* manages the text to be displayed on the graph server and its location. The **Alignment** drop down list boxes select the vertical and horizontal alignment options to be applied. The **Line spacing** field determines the distance between multiple text lines. The actual text to be displayed is specified in the **text edit field** at the bottom of the frame. The text edit field permits specification of multiple text lines and it is subject to the Simulation state context,

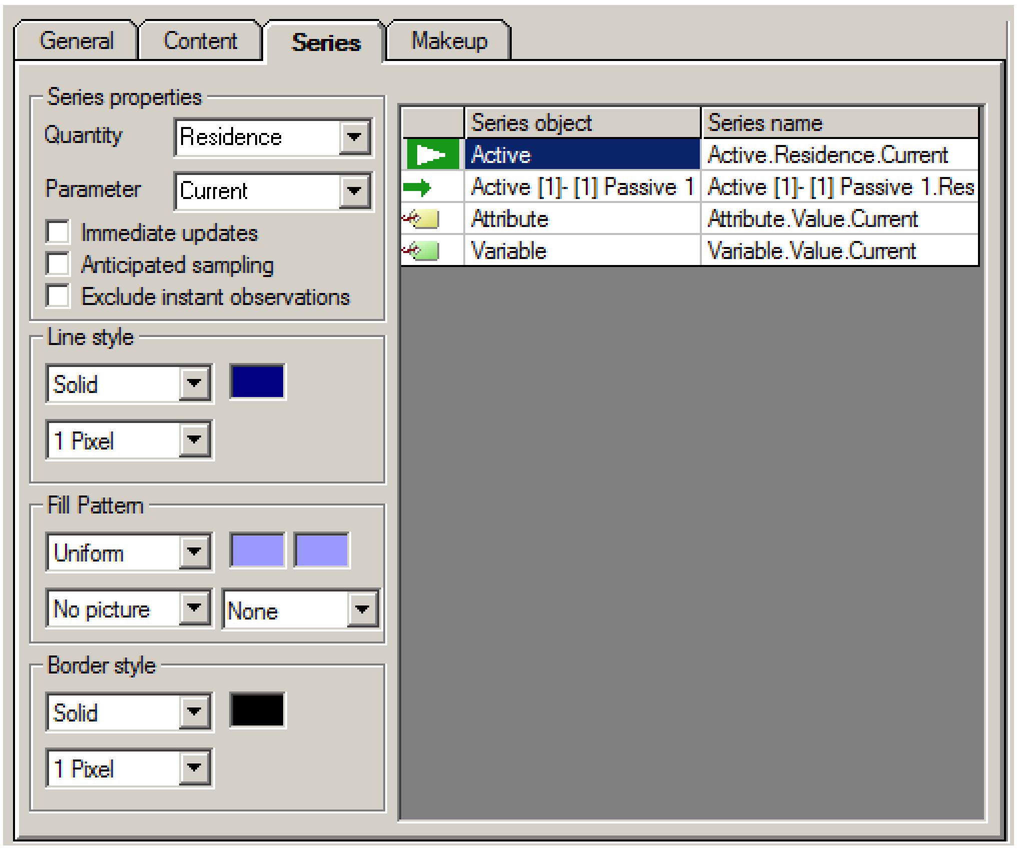
Simulation clock and series data are specified in the text field by using the following content placeholder strings, which all start with the special character *$*:

• *$t*	Simulation time
• *$T*	Clock time
• *$S#*	Current value of data series number #
• *$N#*	Name of data series number #

The first space character succeeding a content placeholder string is ignored. The placeholder string can be followed by a formatting placeholder string, as given in the section Formatting by placeholder strings. The formatting placeholder string is closed by the another *$* character. Only a single named clock format placeholder string (such as *Long Date* and *Short time*) can be used to format the string generated by a content placeholder. However, there is no limit on the number of content placeholder strings used for a graph server**.** The formatting placeholder strings "*simtime*, *st*, *T* and count formats cannot be used to format content placeholders.

4.5.3 Series properties

Data series feed simulation data to graph servers. A graph server can have multiple data series, which can be exhibited simultaneously in the server. Data series of a graph server are managed on the Series tab page. The Series tab is available only if a single graph server is selected on the Context worksheet. The tab page presents a list of the data series of the server and manages the properties of these data series.


General | Content | **Series** | Makeup

Series properties
Quantity: Residence
Parameter: Current
☐ Immediate updates
☐ Anticipated sampling
☐ Exclude instant observations

Line style
Solid
1 Pixel

Fill Pattern
Uniform
No picture | None

Border style
Solid
1 Pixel

	Series object	Series name
▶	Active	Active.Residence.Current
➡	Active [1]- [1] Passive 1	Active [1]- [1] Passive 1.Res
	Attribute	Attribute.Value.Current
	Variable	Variable.Value.Current

Series grid

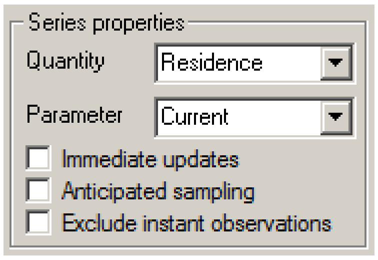
The series grid is located on the right hand side of the tab page. The grid displays all data series defined for the selected graph server. The first and second column of the grid display respectively an icon representing the series object and the name of the series object. The third column displays the name of the data series.

The Series object can be a server or link object, or a variable or attribute component. The server or link objects in the Worksheet objects frame, and the variable and attribute components in the Component repository can be used to create data series by drag-drop operations. If an object is dropped onto the empty area in the series grid, a new data series is created, with the dropped object as series object. If the item is dropped on an icon in the first grid column, a new Data series is inserted at the location of the drop row. If an object is dropped on a grid cell in the column labeled *Series object*, the series object of the data series is replaced by the dropped object. Multiple series items can be added using the **Create data series set** command of the pop-up menu of the server and link browsers. This command creates Data series for all selected objects. Data series are deleted using the pop-up menu or by pressing the **Delete key**. The list order of the series items may be changed by the **Arrow buttons** at the bottom of the window.

Data series for which the series object is an attribute component will generate data for a specified entity. Assignment of an entity to an attribute series is performed by scripting, using the Graph server procedure `AttibuteEntity`.

The other control items on the Series tab page present properties of the data series that are selected in the series grid. If multiple selected series items do not have a uniform value for a specific property the keyword <*various*> is displayed and check boxes are grayed out. Modifications made to a control item in the frame affect all data series selected in the grid.

The series properties frame presents properties associated with the method of data supply by the series object.



Quantity

Defines the Quantity property of the Series object to be represented by the Data series. The Series object type determines which values are available for the quantity property. They are identical to the recordable statistical properties of the Series object, although graph servers receive data independently of statistics recording. Data series with a server as series object have the additional value *Status* for the Quantity property. This value denotes the server status as an integer number, defined as *-1* for the *Disabled* server status, *0* for the *Idle* status, and *1* for the *Busy* status.

A local variable is assigned to the Quantity property of a data series with a server or link as Series object, by specification of a variable component in the Quantity combo box. This is done by typing the component name or dragging a variable component into the combo box.

Parameter

Defines the series parameter of the data series. The available series parameters are identical to the available statistical parameters. However, for the parameter property of data series, the term *Current* is preferred over *Pending*, because data series supply data only when the pending observation is recorded, such that the term *Pending* has little meaning for graph servers.

Attribute and variable components can have non-numerical values, which are ignored for chart-type Style values. For *Time-series line* charts, such data yield a discontinuous line for the parameter property value *Current*.

Immediate update
If this option is applied, an observation recording for a data series causes an immediate update of the graph server.

Anticipated recording
This option influences the parameter evaluation method for a number combinations of Quantity and Parameter values. Some quantity property values are discrete by nature in the sense that their parameter values change stepwise. These quantities are the three object state properties *Population*, *Utilization* and *Dimension*, the *Status* property of servers, and the *Value* property of components. If displayed as a function of time, the resulting line will exhibit a stair stepping pattern (except for the Time-averaged parameter). Whether statistical parameters for such quantities should express the simulation state before or after the quantity change is open for project-specific interpretation. The former is applied by default. Application of this option selects the alternative. The option is closely related to the Pending value tallying statistics recording options. Application of the option has no effect on the *Current* and *Time-averaged* parameter values

The option also affects evaluation of the *Current* parameter of the *Residence* Quantity. By default, a Current Residence series presents only the residence time of entities being removed from storage in the Series object. With this option applied, a *Current Residence* series presents the total residence time of all entities stored in the Series object. The option is ineffective for the Residence quantity in frequency histogram charts.

Exclude instant observations
This option forces exclusion of zero duration observations for all series quantities. The purpose of this option is identical to the Instant change tallying statistics recording options. Application of the option has no effect on evaluation of the series parameters: *Arrivals*, *Time-averaged* and *Fraction*.

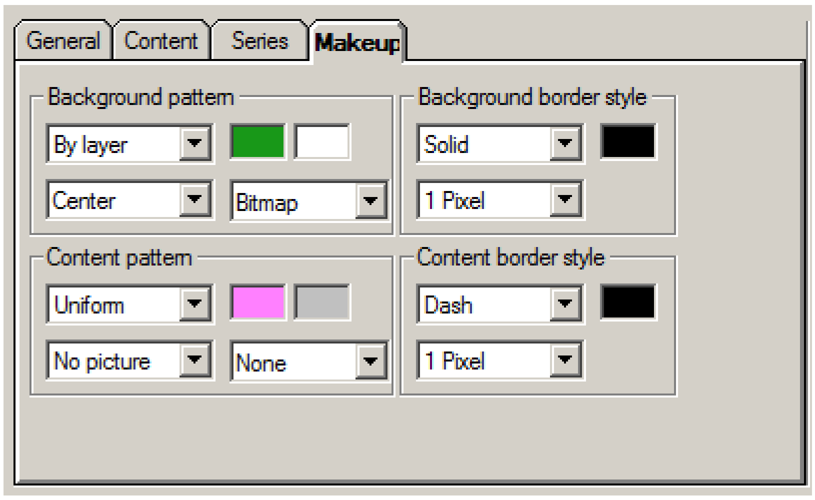
Line style
The frame labeled *Line style* manages the line display method of the data series in a *Time-series line* chart. The control items in this frame behave in the same way as the corresponding items for the content Curve style.

Pattern
The frame labeled *Fill* p*attern* manages the fill pattern properties of data series columns for the graph server. The combo box at the top determines the **gradient properties** of the fill pattern. The **primary color** and **gradient color** are set in the adjacent color selection boxes. At the bottom are two combo boxes that control the display of bitmaps. The left combo box determines the **picture fill style**. The options are *None*, *Center* (picture in center without resizing), *Stretch* (fit picture with aspect ratio preserved), *Fill* (fit picture without maintaining aspect ratio), *Tile*, and Shrink s*tretch* (center, or stretch if larger than the container). The **picture component** to be displayed is selected in the adjacent combo box.

Border style
The frame labeled *Border style* manages the border display method for data series columns for the graph server. The control items in this frame behave in the same way as the corresponding items for the content Curve style.

4.5.4 Makeup

The Makeup tab page controls the display of the background of the graph server. The server has a rectangular content area where content text and chart data are plotted. The content area and the background area of the server can be composed independently with gradient colors, various picture configurations, and border lines in different styles.



Background pattern: By layer, Center, Bitmap

Background border style: Solid, 1 Pixel

Content pattern: Uniform, No picture, None

Content border style: Dash, 1 Pixel

Pattern

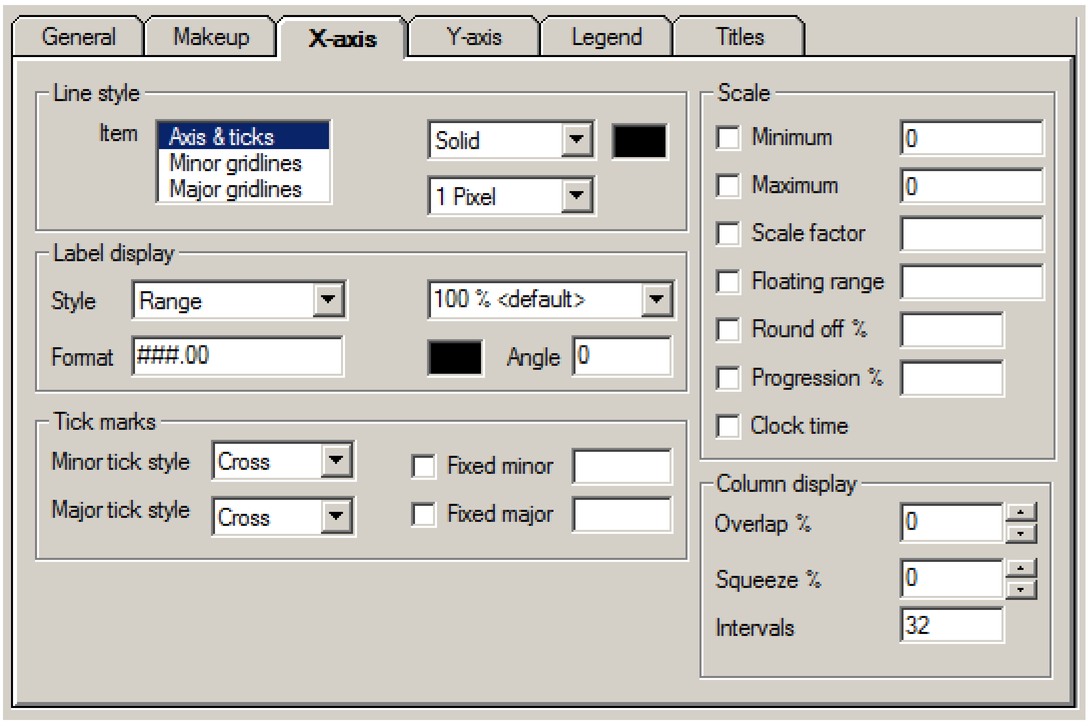
The *Pattern* frames manage the fill pattern properties of a graph area. The control items in this frame behave in the same way as the corresponding items for the series Fill pattern.

Border style

The *Border* style frames manage the border display method of a graph area. The control items in this frame behave in the same way as the corresponding items for the content Curve style.

4.5.5 Axes

The X-axis and Y-axis tab pages controls the properties of the axes for the graph Styles that represent charts. The control items on the tab page determine a variety of properties, such as the axis line style, tick marks, label style and scale range options.



Line style
Item: Axis & ticks, Minor gridlines, Major gridlines
Solid
1 Pixel

Label display
Style: Range
100 % <default>
Format: ###.00
Angle: 0

Tick marks
Minor tick style: Cross
Major tick style: Cross
☐ Fixed minor
☐ Fixed major

Scale
☐ Minimum: 0
☐ Maximum: 0
☐ Scale factor
☐ Floating range
☐ Round off %
☐ Progression %
☐ Clock time

Column display
Overlap %: 0
Squeeze %: 0
Intervals: 32

Line Style

The frame labeled *Line style* sets the line style for the axis and for gridlines. The item list box at the top of the frame allows selection of multiple items for formatting. The control items in this frame behave in the same way as the corresponding items for the content Curve style.

Label display

The **Style** combo box manages the display style of labels on the axis. The default value *Major ticks* causes labels to be displayed at major tick marks. No labels are displayed if the *None* option is selected. The effect of selecting the *Range* value depends on the Style property of the graph server. For the x-axis of the *Time-series line chart* style, and for the y-axis, selecting this option forces display of the minimum and maximum values of the scale range only. For *Frequency histogram* charts the *Range* label style causes labels to be displayed at interval boundaries, as opposed to the middle of an interval. For the x-axis on *Column* charts there is no difference in the label display behavior of the *Major* and *Range* options. The **Format** text field allows control of the numerical format of the labels. By specification of a formatting placeholder string to the text field, the labels can be formatted in the same manner as Time display formatting. The **Font** control items on the right of the frame behave in the same way as the corresponding items for the content Font. The **Angle** text field sets the inclination angle of the label in degrees. The Angle text field accepts integer values between -90 and +90.

Tick marks

The frame labeled *Tick marks* determines the display of tick marks on the axis. The **Minor/major tick style** combo boxes set the tick mark formats. By default, the number of tick marks displayed is determined automatically. The **Fixed minor/major** control items allow fixing the number of tick marks displayed on the axis. For the x-axis, the tick mark number can only be fixed for the *Time-series line chart* Style value. Minor tick marks are displayed only if major tick marks are displayed.

The frame labeled *Scale* determines the scale range of the axis.

Minimum/Maximum

By default, the scale range is adjusted automatically to extend to the chart data range. Application of the Minimum and Maximum properties assigns fixed values to the scale range. These properties are not available for the x-axis of the *Value column* Style value.

Scale factor

Used to apply a scaling factor to the time ordinate. If applied, the time parameter displayed on the axis is multiplied by the number specified in the associated text field. The Scale factor property is ignored if the Clock time property has been applied to the graph server, in conjunction with a Time unit for the clock time. This property is available only for the x-axis of the *Time-series line chart* Style.

Floating range

Fixes the scale range of the time axis for the *Time-series line chart* Style. This property adjusts the lower scale boundary to limit the scale range to the value specified in the associated text field. This property is not applicable in conjunction with the Minimum and Maximum properties. By default, the upper scale boundary coincides with the maximum time value of the plotted data set, but the upper scale boundary can be adjusted by application of the Progression property.

Round off (%)

By default the scale range of the axis is adjusted automatically to extend to the simulation data range. Application of this property activates rounding off of the scale range by a percentage relative to the data range, as specified in the associated text field. For the x-axis, this property is available only the *Time-series line chart* Style value.

Progression %

Controls the scale range adaptation of the time axis for graphs of the *Time-series line chart* Style in case the Floating range property is applied. When data is supplied to the graph server, with time values outside the current scale range, the scale minimum is increased, such that the updated scale range overshoots the data range by a percentage equal to the value specified in the associated text field.

Clock time

By default the x-axis parameter of such charts is the simulation time. Application of this property selects the clock time as x-axis parameter. Only available for the x-axis of the *Time-series line chart* Style.

Fractional

By default, histogram charts display the interval frequencies in absolute numbers. Application of this property forces the frequency value to be displayed as fraction. Only available for the y-axis and for Style values that represent a histogram chart.

The frame labeled *Column display* manages the display properties of columns for chart types other than the *Time-series line chart* Style.

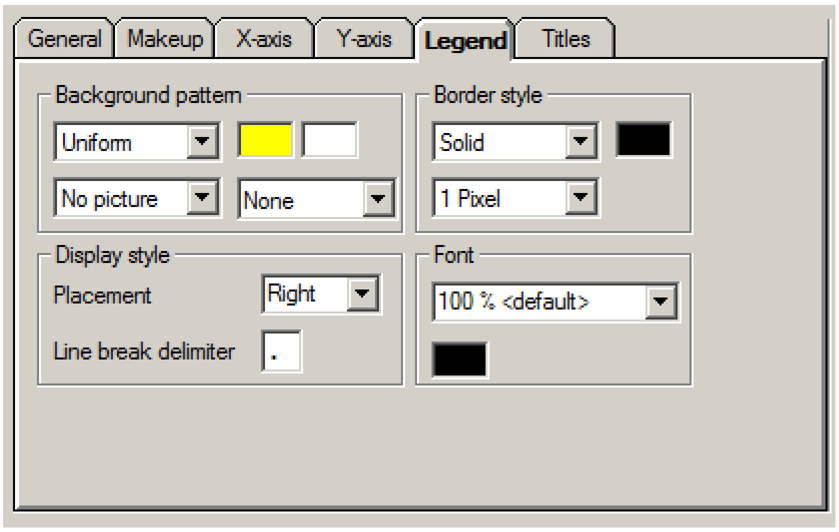
Overlap %
Determines the column overlap of columns in chart. Valid range: -100 to 100 %. Only available for the x-axis and for Style values that represent data by columns.

Squeeze %
Determines the width of columns with respect to the x-axis tick mark spacing. Valid range: 0 to 100 %. Only available for the x-axis and for Style values that represent data by columns

Intervals
Determines the number of intervals for histogram graph Styles. The value to be specified in the associated text field is an integer in the range 2 to 1024. If not both the Minimum/Maximum checkboxes are checked the interval number must be a power of 2.

4.5.6 Legend

The **Legend** tab page controls the position and display properties of the legend of charting graph servers.



Background pattern: Uniform, No picture, None
Border style: Solid, 1 Pixel
Display style
Placement: Right
Line break delimiter: .
Font: 100 % <default>

Background pattern
The frame labeled *Background pattern* controls the legend background. The control items in this frame behave in the same way as the corresponding items for the series Fill pattern.

Placement
Determines the position of the legend with respect to the Content area. The Placement value *None* hides the legend.

Line break delimiter
The character specified in the associated text field serves as line break delimiter for the series name in the legend. The default is the period character.

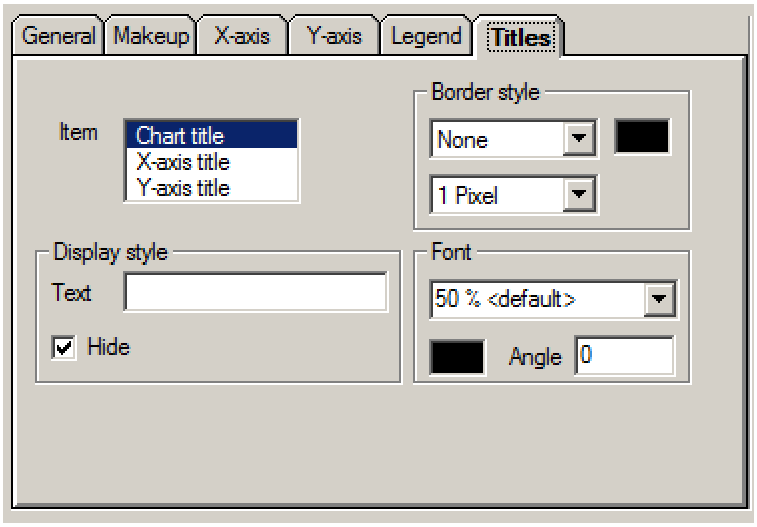
Border style
The frame labeled *Border style* sets the line style for the legend border. The control items in this frame behave in the same way as the corresponding items for the content Curve style.

Font

The frame labeled *Font* manages the font properties of the legend text. The control items in the frame behave in the same way as the corresponding items for the content Font.

4.5.7 Titles

The Titles tab page manages the display of titles on charting graph servers.



Item: Chart title, X-axis title, Y-axis title

Border style: None, 1 Pixel

Display style: Text; Hide ☑

Font: 50 % <default>; Angle: 0

The **Item** list box at the top of the frame allows selection of multiple items for formatting.

Display style

The title text is set in the text field labeled **Text**. The **Hide** check box is used to disable the display of a chart title.

Border style

The frame labeled *Border style* determines the display style of a border enclosing the title. The control items in this frame behave in the same way as the corresponding items for the content Curve style.

Font

The frame labeled *Font* determines the text display style of the selected titles in the item list box. The control items in the frame behave in the same way as the corresponding items for the content Font. The **Angle** text field sets the inclination angle of the label in degrees. The text field accepts integer values between -90 and +90.

4.5.8 Graph server layout

The size of the graph server areas for display of content, titles, axis labels and the legend may be modified either in the Graph window or on the worksheet. The mouse icon changes if the mouse pointer hovers over one of the section boundaries. The alternate mouse pointer icon indicates in which direction the section boundary can be moved by holding down the left mouse button and dragging it to another location. In the graph window, the area section boundaries will automatically be shown as dotted lines, if the mouse is held over a section boundary for a short time. The section boundaries display can also be toggled by pressing the space bar. On the worksheet, section boundaries are displayed in the server resize mode.

If the graph server is clicked with the right mouse button (on the worksheet only in the server resize mode), a **pop-up menu** with the following switches and commands appears:

Lock section boundaries

Disables manual adjustment and hides the section boundaries.

Hide unused section boundaries

Checking this menu item hides the section boundaries for the legend and title areas, if these elements are hidden. Not available for the graph server Style value *Text.*

Mirror section boundaries

Enables mirrored arrangement of the content area section boundaries. Only available for the graph server Style value *Text.*

Show boundaries on mouse hover

Toggles the automatic section boundaries display upon mouse hovering. Only available for the Separate graph window.

Reset section boundaries

Returns all graph section boundaries to their default locations.

4.6 Component properties

The **Component** tab provides access to Renque component objects. Components are user-creatable project elements which are not displayed on the Worksheet. The tab displays the properties of the components selected in the Component repository. The component properties are displayed in frames, which are only visible if all selected components are of the same type. If the selected components do not have a uniform value for a specific property, the keyword <*various*> is shown in text fields, and check boxes are grayed out. Changes made to the control items are applied to all selected components.

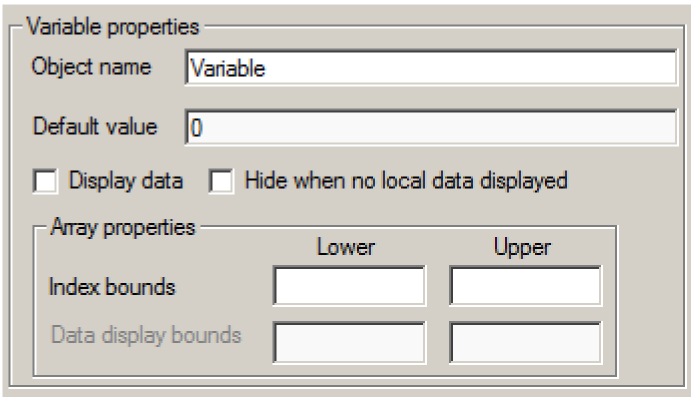
The properties of the Renque component types are discussed in separate topics:

- Variable
- Attribute
- Distribution
- Schedule
- Picture

4.6.1 Variable properties

Variable components are used to store simulation data. Data can be stored into and read back from variables through simple scripting statements.

The Variable properties frame is shown if one or more variable components have been selected in the Component repository. The frame has a text field to specify the default value and a number of controls, which determine how variable data is presented in the Variable data sheet on the Data tab.


Variable properties

Object name: Variable

Default value: 0

☐ Display data ☐ Hide when no local data displayed

Array properties

	Lower	Upper
Index bounds		
Data display bounds		

Object name
Name of the component.

Default Value
Default value of the component. Permitted values for the default property are integer and floating point numbers, strings, boolean keywords (True or False) and clock dates or time values. The format of the specified value is recognized automatically. String values not representing a number, a boolean keyword or a date/time value, may be entered without quotation marks.

Display Data
Application of this property is required for the component to be represented on the Data tab and displayed in the Variable data sheet.

Hide when no local data displayed
Hides the variable component in the Variable data sheet in case the sheet displays no local values for the component.

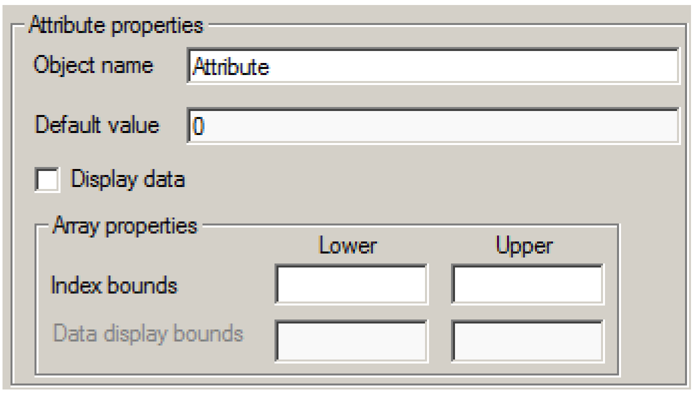
Index bounds
Defines the array dimension bounds for variables. The lower and upper text fields accept any integer number as long as the lower bound is smaller than or equal to upper bound value. If both fields are left empty the component is not an array.

Data display bounds
Restricts the display of array variables values in the Variable data sheet to a range of indices as specified by the text fields labeled lower and upper. If any of these fields is left empty, data display is not limited for the corresponding index bound of the variable.

4.6.2 Attribute properties

Attribute components are used to store simulation data in entities. Data can be stored into and read back from entity attributes by simple scripting statements.

The Attribute properties frame is shown if one or more attribute components have been selected in the Component repository. The frame has a text field to specify the default value and a number of controls , which determine how attribute data is presented in the Entity data sheet on the Data tab.


Attribute properties

Object name: Attribute

Default value: 0

☐ Display data

Array properties

	Lower	Upper
Index bounds		
Data display bounds		

Object name
Name of the component.

Default Value
Assigns a default value to the component. Permitted values for the default property are integer and floating point numbers, strings, boolean keywords (True or False) and clock dates or time values. The format of the specified value is recognized automatically. String values not representing a number, a boolean keyword or a date/time value, may be entered without quotation marks.

Display Data
Application of this property is required for the component to be represented on the Data tab and displayed in the Entity data sheet.

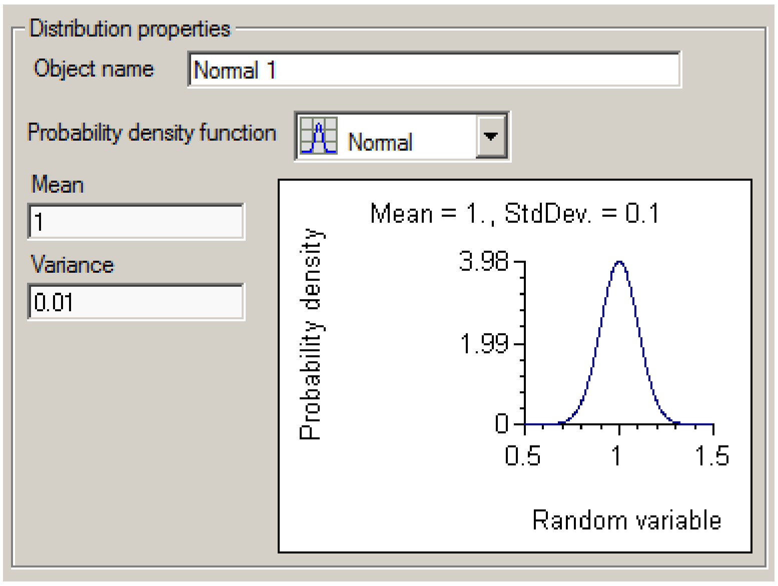
Index bounds
Defines the array dimensional bounds for attributes. The lower and upper text fields accept any integer number as long as the lower bound is smaller than or equal to upper bound value. If both fields are left empty the component is not an array.

Data display bounds
Restricts the display of array attribute values in the Entity data sheet to a range of indices as specified by the text fields labeled lower and upper. If any of these fields is left empty data display is not limited for the corresponding index bound of the attribute.

4.6.3 Distribution properties

Distribution components are objects that generate a random number when evaluated. Distribution components are defined by a probability density distribution function (pdf), which determines the distribution of the numbers generated by the component.

The Distribution properties frame is shown if one or more distribution components have been selected in the Component repository. The frame contains the **Probability density distribution** combo box at the top-left side, a set of **distribution parameter** fields, and a **Preview pane** on the right-hand side. The distribution parameter properties are subject to the Simulation state context.


Distribution properties
Object name: Normal 1
Probability density function: Normal
Mean: 1
Variance: 0.01

Object name
Name of the component.

Probability density function
This combo box selects the pfd function for the distribution component. The available distribution functions are given in the table below. In this table, the parameter x indicates the random value. Where not indicated otherwise, x is a real number without range limits. The symbol Γ represents the Gamma function.

Name	***Parameters***	***Probability density***	***Restraints***
Exponential	Mean λ	$\lambda \cdot \exp(-\lambda \cdot x)$	$\lambda >= 0$, $x >= 0$
Triangular	Minimum a Modus m Maximum b	$\frac{2 \cdot (x - a)}{(b - a) \cdot (m - a)}$	$a <= x <= m$
		$\frac{2 \cdot (b - x)}{(b - a) \cdot (b - m)}$	$m < x <= b$
Uniform	Minimum a Maximum b	$\frac{1}{b - a}$	$a <= x <= b$
Normal	Mean μ Variance σ^2	$\frac{1}{\sigma \cdot \sqrt{2 \cdot \pi}} \cdot \exp\left[\frac{-(x - \mu)^2}{2 \cdot \sigma^2}\right]$	$\sigma > 0$
Weibull	Shape α Scale β	$\alpha \cdot \beta^{-\alpha} \cdot x^{\alpha - 1} \cdot \exp\left[-\left(\frac{x}{\beta}\right)^{\alpha}\right]$	$\alpha > 0$, $\beta > 0$ $x >= 0$
Binomial	Trials N Probability p	$\frac{N!}{x! \cdot (N - x)!} \cdot p^x \cdot (1 - p)^{N - x}$	$0 <= p <= 1$ N = 0,1,2 ; x = 0,1,2..N
Poisson	Shape ν	$\frac{e^{-\nu} \cdot \nu^x}{x!}$	$\nu >= 0$ x = 0,1,2...
Gamma	Shape k Scale θ	$\frac{x^{k-1} \cdot \exp\left(\frac{-x}{\theta}\right)}{\theta^k \cdot \Gamma(k)}$	$k > 0$, $\theta > 0$, $x >= 0$
Beta	Shape a Shape b	$\frac{\Gamma(a + b)}{\Gamma(a) \cdot \Gamma(b)} \cdot (1 - x)^{b - 1} \cdot x^{a - 1}$	$a > 0$, $b > 0$
Piecewise	i = 1...N nodes (r_i, p_i)	j = 1...N-1 linear segments	$r_{j+1} >= r_j$, $r_1 <= x <= r_N$

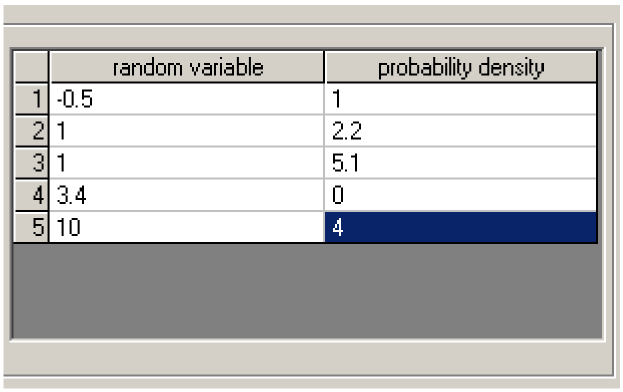
The *Piecewise* distribution function is a piecewise linear function, consisting of a finite number of linear segments. The end points of adjacent segments coincide, such that the segments form a continuous curve, which maps the probability density as a function of the random variable.

Distribution parameters

Parameter data may by entered in the text fields below the pdf combo box. The available parameters depend on the selected distribution function. The parameter value ranges allowed are listed in the right-most column of the table above. The evaluating components variable and attribute may be assigned to all parameters of any distribution function.

If the data entered in one or more parameter fields are inconsistent with the selected distribution function, the parameters concerned are displayed in an alternative color and a message is displayed in a **status bar** at the lower window edge. Pressing the **Esc key** cancels all changes made and restores the previous values.

The parameters of the *Piecewise* probability density distribution function are presented in a grid, which appears when the *Piecewise* item is selected in the pdf combo box. The grid rows specify the coordinate pairs of the nodes of the piecewise curve. The first and last grid rows represent the two end points. Other rows represent segment curve segment intersections. The first column specifies the **Random variable** in order of increasing value. The second column specifies the corresponding **Probability density**. When applied in the simulation, the probability density values specified in the grid are normalized to meet the requirement of unity surface area under the curve.



	random variable	probability density
1	-0.5	1
2	1	2.2
3	1	5.1
4	3.4	0
5	10	4

The cells of the node grid are edited by double clicking a cell, or by pressing a key while a cell is selected. Invalid entries are indicated by an alternative text color. Grid rows that have an invalid entry are ignored in evaluation of the distribution component. Rows can be inserted and deleted by **pop-up** menu commands of the grid.

The **Preview chart** displays the pdf-curve for each distribution component selected in the Component repository. The chart is cleared if any of the distribution properties are modified by the controls on the frame. The chart is repainted when the modified properties are applied, by pressing the **Enter key** in a parameter control or by moving focus back to the repository. Pressing the **Esc key** cancels all changes made to the selected distribution components and repaints the preview chart.

4.6.4 Schedule properties

Schedule components execute user-defined scripts at specific time points in the simulation. A schedule component can have multiple timing entries, or schedule lines. A schedule line is defined by a Timing property and a series of schedule scripts. A schedule component executes the scripts of a schedule line consecutively by a single calendar event at a simulation time determined by the Timing property of the schedule line.

The schedule frame is shown if one or more schedule components have been selected in the Component repository. The schedule properties are defined by the **Schedule grid** and a number of additional controls on the frame.

Object name
Name of the component.

Priority
Determines the event priority of simulation events created in the Event calendar by the schedule. Possible values: integer number in the range -16000 to +16000.

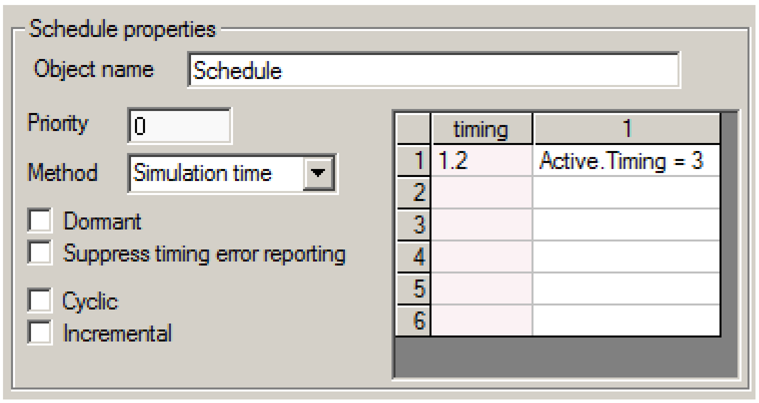
Method
Selects the schedule timing method. There are three options:

- Simulation time.
  The *Simulation time* method is the default. It uses the simulation time reference frame for schedule timing evaluation, which requires the timing properties of the schedule lines in the schedule grid to be specified as simulation time values.

- Clock time
  The *Clock time* method uses the clock time reference frame for the schedule timing mechanism. Application of the *Clock time* method renders the Recurrence options frame visible, provided a Time unit has been specified for the simulation clock.

- Simulation state
  Under application of the *Simulation state* method execution of the schedule is driven by changes in the simulation state, and no timing is applied. The timing column in the below-mentioned schedule grid is hidden and the Simulation state frame is shown.

Schedule grid
This grid displays the schedule lines of the component selected in the Component repository. The grid is hidden if multiple schedule components are selected.


Schedule properties

Object name: Schedule

Priority: 0

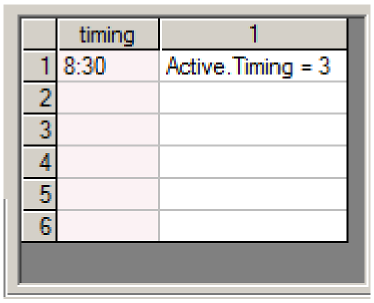
Method: Simulation time

☐ Dormant
☐ Suppress timing error reporting
☐ Cyclic
☐ Incremental

	timing	1
1	1.2	Active.Timing = 3
2		
3		
4		
5		
6		

The properties of the schedule lines are organized in grid columns. The first column displays the Timing property. The other columns contain schedule scripts. The Timing property is specified either as a number or as a script that evaluates to a number.

The Timing property of the schedule lines of the schedule component represents the simulation time if the *Simulation time* Method has been selected. For the *Clock time* Method the Timing property, represents the clock time, and is specified in the clock format of the regional system settings, provided a Time unit has been specified for the simulation clock.



	timing	1
1	8:30	Active.Timing = 3
2		
3		
4		
5		
6		

If no Time unit has been specified the Timing property represents the absolute dimensionless clock time for the *Clock time* Method.

Rows and columns can be inserted and deleted by commands in the right-click pop-up menu of the grid. The cells of the schedule grid may be edited by double-clicking the cell or pressing the **Enter key**. Editing methods for the schedule scripts are discussed in the Script editing topic.

Dormant

Disables initialization schedules. By default the schedule process is started automatically when a simulation replication starts. If this property is applied the schedule can be activated only by the schedule scripting procedure `Run`.

Suppress timing error reporting

Disables error reporting for timing evaluation run-time errors for the schedule. A schedule causes a runtime error if the Timing value of one of its schedule lines is smaller than the Timing value applied on the preceding schedule line. This error inhibits execution of all schedule scripts of the schedule line involved, and creates an entry in the runtime error listing. Application of the error suppression option prevents the latter.

Cyclic

Enables cyclic schedule execution. By default the schedule process is terminated when the last schedule line has been executed. If this property is applied, execution continues from the top after execution of the last schedule. The Cyclic property is only available for the *Simulation time* Method.

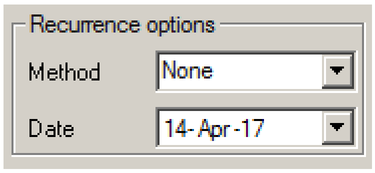
Incremental

Enables incremental timing interpretation. By default the Timing values of the schedule grid represent absolute time values. If this property is applied the Timing values represent intervals between execution of the schedule items. The Incremental property is only available for the *Simulation time* Method.

Recurrence options

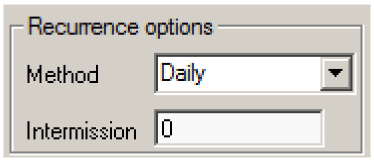
This frame is available for the *Clock time* Method if a physical Time unit has been specified for the simulation clock. The selection in the recurrence **Method** combo box determines the recurrence style of the schedule. The available recurrence methods are *None, Daily, Weekly, Monthly* and *Yearly*. The methods *None, Monthly* and *Yearly* are available only if the Use Calendar property has been applied to the simulation clock. The composition of the frame varies with the selected recurrence Method.

The recurrence method *None* will result into execution of the schedule on a specified date. The schedule date is set by the **Date** drop-down control in the frame.



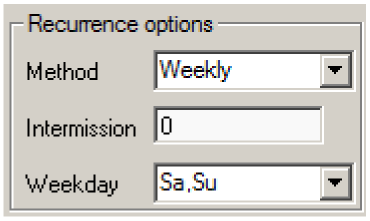
Method: None
Date: 14-Apr-17

The other recurrence methods can yield repetitive schedule execution. The *Daily* recurrence method only requires specification of the Intermission property. The **Intermission** text field defines the number of skipped recurrences between executed recurrences, where all any recurrences are executed for the default value 0. The Intermission property is also available for the other recurrence methods, discussed below.



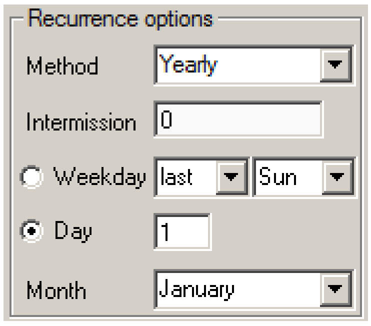
Method: Daily
Intermission: 0

The *Weekly* recurrence method requires specification of one or more weekdays for schedule execution.



Method: Weekly
Intermission: 0
Weekday: Sa,Su

The *Monthly* and *Yearly* recurrence methods provide the means to specify a recurrence day, by selecting the **Weekday** or the **Day** option respectively. The *Yearly* recurrence style requires specification of the recurrence month as well.



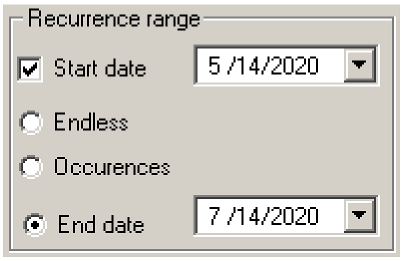
Method: Yearly
Intermission: 0
Weekday: last Sun
[✓ Day]: 1
Month: January

The schedule creates a calendar event at the start of each recurrence day for all recurrence styles, regardless of the timing properties of the schedule lines. Intermission is applied initially, if the first schedule line requires execution earlier than the clock Timetable dictates for the start of a replication.

Recurrence range

The Recurrence range frame defines the operative time span for a Clock based schedule. The frame is available for all but the *None* recurrence methods, provide the

Use Calendar property has been applied to the simulation clock. If the **Start date** box is checked, the recurrence starts on the date specified in the associated text field, rather than on the replication start date. Termination of the recurrence range is determined by the selected option button in the frame. No termination is applied for the default option **Endless**. The **Occurrences** option allows specification of the number of occurrences, and the **End date** option allows specification of a recurrence range end date.



Recurrence range

[✓] Start date 5 /14/2020

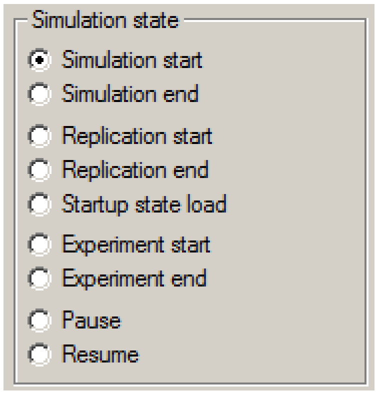
( ) Endless

( ) Occurences

[✓ End date] 7 /14/2020

Simulation state

This frame is available for the *Simulation state* value Method. This method will cause execution of all schedule lines when the simulation assumes a specified simulation state. The available simulation conditions for schedule execution are indicated in the frame.



Simulation state

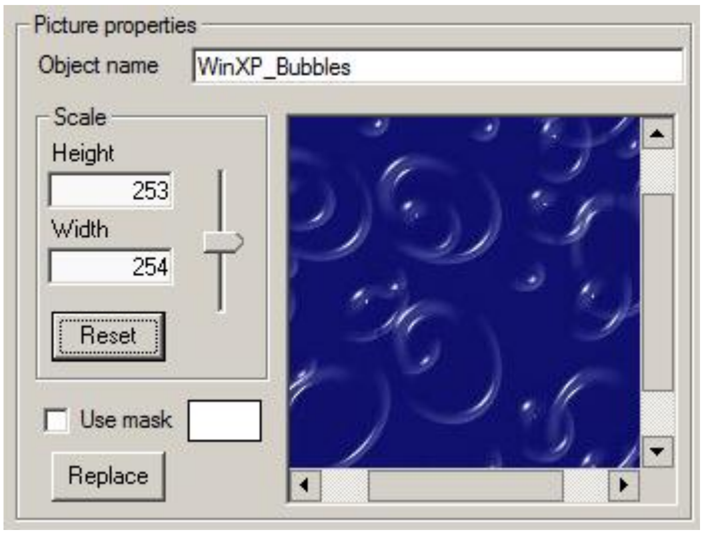
[✓ Simulation start]
( ) Simulation end
( ) Replication start
( ) Replication end
( ) Startup state load
( ) Experiment start
( ) Experiment end
( ) Pause
( ) Resume

The simulation state options include Start/End-pairs for the options **Simulation**, **Replication** and **Experiment**, a **Pause/Resume** option pair, and the **Startup state load**. For all options, the schedule items are executed after the simulation assumes at the corresponding status. The **Startup state load** option is effective only if the Shared startup time property has been enabled, in which case the schedule is executed in the place of the **Replication start** option, for replication numbers > 1.

4.6.5 Picture properties

Picture components can be used to represent server objects and entities on the Worksheet and to dress up graph servers. During a simulation, a picture component can be assigned to a server or an attribute object by respectively the scripting procedures `Picture` and `Icon`. The server picture can also be set by the Server picture item on the Object properties console.

The Picture properties frame is shown on the Components tab if one or more picture components have been selected in the Component repository. The Component properties frame contains a picture preview box and a set of additional controls.



The **Picture preview box** presents an image of the picture selected component. If more than one picture component have been selected in the Component repository, no picture is displayed.

Object name
Name of the component.

Height, Width
Define the scale size of the selected picture components. Application of the **Maintain aspect ratio** option of the pop-up menu of the Picture preview box forces preservation of the height over width ratio of the picture when changing the height or the width value. The slider control in the Scale sub-frame can be used to reduce or increase the size of the picture by a maximum factor of approximately 10.

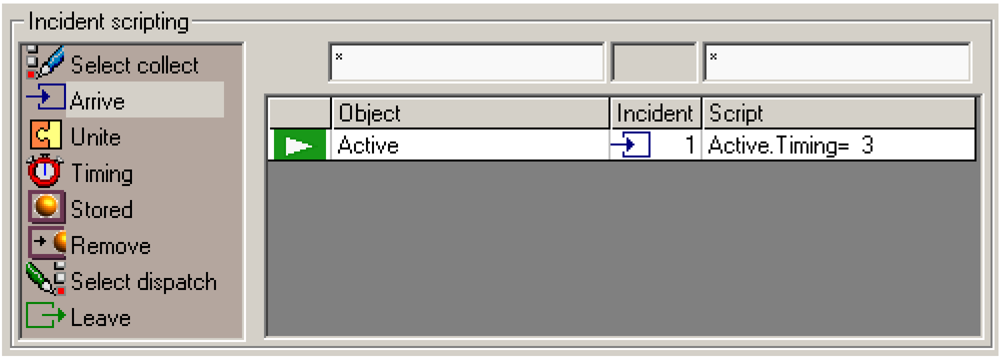
Use mask
Enables transparency for the picture. If applied, the picture is displayed with the mask color as transparent color on the Worksheet. The mask color is indicated in the adjacent color box and can be changed with the standard Windows color selection utility, which is opened by clicking on the associated **Mask color box**. The mask color can also be selected by clicking inside the picture.

Replace
Opens a file selection utility to replace the current image by another picture file stored on disk.

4.7 Incident scripting

The **Scripting** tab on the Object properties console displays the Incident scripting frame when selected. The controls on this frame facilitate the management of Incident scripts. Incident scripts are short commands in the *Microsoft Visual Basic* scripting language. They are used to implement particularities in the behavior of the project, in aspects that are not controllable by the standard object properties. Incident scripts are assigned to a link or server object. An object can have multiple incident scripts for every incident type, which are executed consecutively upon occurrence of the incident. This topic concentrates on the management of incident scripts. Script coding techniques are discussed in the Scripting topic.

The Incident scripting frame encloses a table of the available incident types and a list of incident scripts.



	Object	Incident	Script
▶	Active	1	Active.Timing= 3

Be default, the **Incident grid** displays all incident scripts defined for objects that have the selected state in the Context worksheet. If the Routing list boxes are shown, the grid displays link incident scripts for the links shown in the selection boxes, regardless of the selection state of the link. The grid has four columns. The first column displays an icon representing the **incident object** and the second column displays its **name**. The third column displays an icon for the **Incident type**, followed by a sequence number. The actual **Incident script** is displayed in the last column.

The **Incidents table**, on the left-hand side of the frame, is used to display and assign the incident type of incident scripts. The available incident types are:

Select collect

For servers, this incident is invoked at the start of the link selection procedure governed by the Collect rule, in the verification stage of the operative collection procedure. The incident does not occur if all collecting links of the server are Mandatory. The incident is invoked for a link object when the link is selected as participating non-Mandatory link. The script entity is not defined for this incident.

Arrive

This incident is invoked when an entity arrives at a link or server object, before any subsequent handling of the entity takes place. The arrival incident occurs with all arriving entities, whether they are stored in the object or not.

Unite

This incident is invoked in the transfer stage of the operative collection procedure, when an entity arriving on a Uniting link or server is united with an entity stored in the object. The incident allows for customization of the uniting process for each united entity by scripting. The stored entity is referenced by the `UniteEntity` function. The arriving entity is the Script entity. The scripting functions `UniteNumerator` and `UniteDenominator` can be used to determine the progress of the uniting routine.

Timing

This incident is invoked prior to evaluation and application of the Timing property of server objects and the Travel time property of link objects.

Stored

This incident is invoked upon storage of an entity as resident in a server object or a link buffer.

Select dispatch

For servers, this incident is invoked at the start of the link selection procedure governed by the Dispatch rule, in the dispatch routine of an active server. The incident does not occur if all dispatching links of the server are Escort links. The incident is invoked for a link object when the link is selected as non-Escort dispatching link.

Remove

This incident is invoked before non-timed removal of an entity from storage in a server or link buffer. Timed entity removal only takes place by Expiration incidents for passive servers and by entity dispatch for active servers. The incident is useful to determine the residual residence time of server residents, using the entity scripting procedure: `Departure`. For links, the incident occurs for all entities removed from the link buffer because entity removal from links is always non-timed.

Leave

This incident is invoked when an entity leaves a server or link object. The Leave incident is the last exercise of the entity in relation to the incident object. The incident occurs with all departing entities, whether they were stored in the object or not. The dispatch routine of active servers may create Escort copies of a dispatch entity. These escort entities are created before the Leave incident is invoked on the dispatch entity, and the departure of escort entities does not invoke another Leave incident.

Scripts may be created, edited and deleted and the sequence, the incident type and the incident object may be modified. Editing methods for scripts are discussed in topic: Script editing.

Incident scripts are created by dragging a object from a control in the Worksheet objects frame, and dropping it on the **Incident grid**. These objects must have the selected state in the Context worksheet. New script items can be added by dropping the object on the empty area in the grid. The selected item in the **Incidents table** determines the incident type of the new script item. An incident script can be inserted before the position of an existing script with the same incident object, by dropping the object on the object icon in the grid. If the object is dropped on the second column, the incident object is replaced by the dropped object.

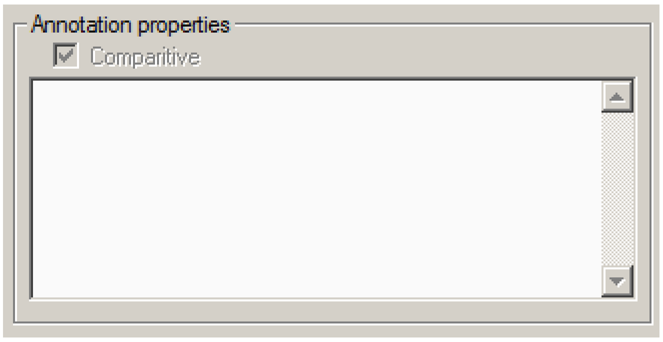
Multiple incident scripts can be created and changed by pop-up menu commands. The **Add incident scripts** pop-up menu item of a control in the Worksheet objects frame will add a script item for all selected objects. In addition, the **Set incident object** item of the pop-up menu changes the incident object of the selected script items to the currently selected object. In a similar fashion, the incident type of all script items selected in the grid can be changed by the **Set incident** command of the pop-up menu of the Incidents table.

By default, the display order of the script items is: first servers, then links, ordered as listed in the Worksheet objects frame. Alternatively, the grid items can be sorted alphabetically by column, by clicking the **top row** of a grid column. The sort column and direction are indicated by a symbol in the top row. The script display in the Object incident grid can be moderated using the three controls above the grid. When a key string is entered in one of the text fields above column 2 and 4, script items of which the cell text does not match the filter key are removed from the grid. The Incident filter control in the middle can be used to restrict script display to a particular incident type. The incident filter is set by pressing the **Page up**/**Page down/Arrow** keys or a **number key** between 1 and 7, when it has the focus, or by drag-dropping an item from the **Incidents table** on the incident filter. Pressing the **0** key or **Delete** clears the incident filter.

Sorting and key string matching are not applied immediately when changes are made to the Incident grid. The grid is only updated when the sort and key string settings are changed and when the **F5** or **Enter** key is pressed on the grid or the filter controls. All sort and filter settings are cleared by the **Reset list** item of the pop-up menu of the grid. If no sorting or display filtering is applied the grid is updated for all changes made to the script items.

4.8 Annotation

The **Annotation** tab on the Object properties console displays the Annotation properties frame when selected. This frame encloses a text field for server annotations. Annotations are useful to store and display general information on server objects, for example as reminder for model developers or to aid model operators in reviewing a model. Annotation is not available for Graph servers.



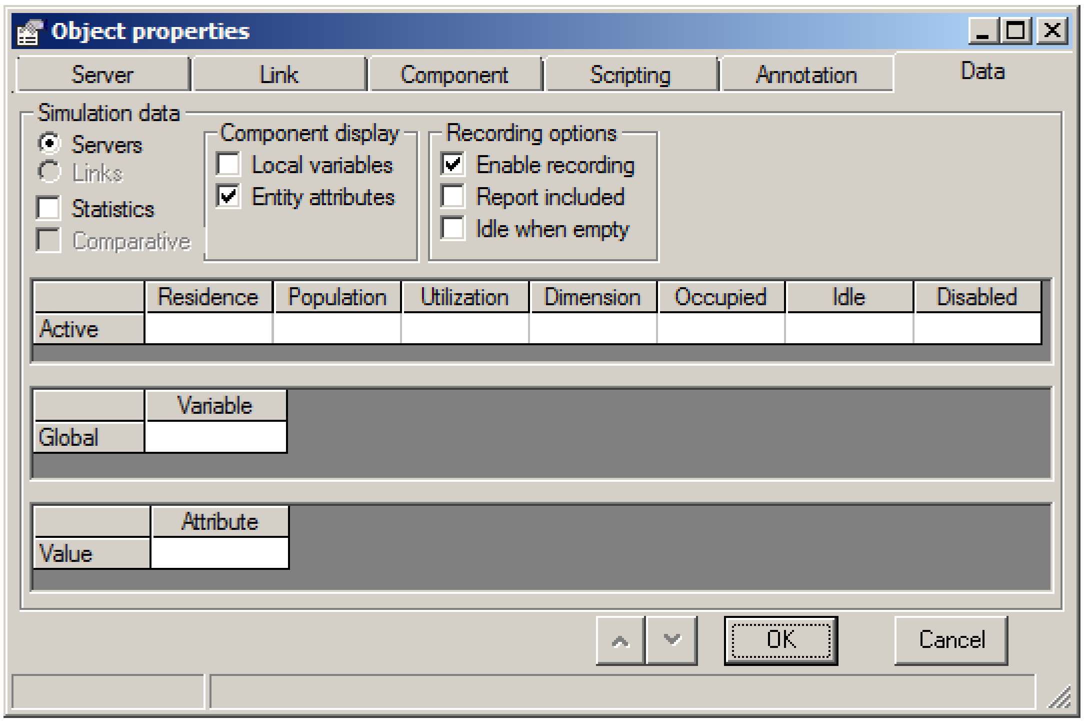
The server annotations are displayed in the text field on tab page.

Comparative

By default, annotations are listed with server title if multiple annotated servers are selected on the worksheet. In that case, the annotation text field is locked. Checking this option unlocks the text field, displaying either the identical annotation value of the selected servers, or the keyword <*various*> if the servers have different annotations.

4.9 Simulation data

The **Data** tab on the Object properties console displays the Simulation data frame when selected. This frame provides access to the simulation results and manages statistics recording of the project.



Simulation data
- [✓ Servers] Links
- Statistics
- Comparative

Component display
- Local variables
- [✓] Entity attributes

Recording options
- [✓] Enable recording
- Report included
- Idle when empty

	Residence	Population	Utilization	Dimension	Occupied	Idle	Disabled
Active							

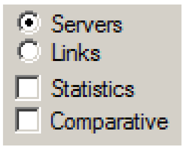
	Variable
Global	

	Attribute
Value	

The control items at the top of the frame shape the way data is displayed and arrange some details of the statistics recording process. The frame also contains three data sheets, which display simulation data in an organized manner. The upper sheet displays data for server and link objects. The one in the middle displays variable component data, and the data sheet at the bottom displays entity information, including attribute component data.

For server and link objects, the frame displays only the property values of objects that have the selected state in the Context worksheet. If these objects do not have a uniform value for one of the check boxes in the sub-frames at the top of the frame, the check box is grayed out. Changes made to the control items are applied to all selected objects.

The group of control items at the top left side of the frame determine the primary data display mode of the frame.



[✓ Servers] Links
Statistics
Comparative

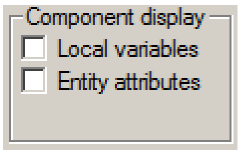
Servers/Links

Selects the object type for data display. The Simulation data frame displays information for either server or link objects. Checking an option button chooses the corresponding object type.

Statistics
Switches to the display of recorded statistics. By default, the data sheets display the current value of object properties. If this option is checked, recorded statistics data are displayed instead. The composition of the data sheets in the Statistics display mode is discussed in topic Display of statistical data.

Comparative
This check box activates the Comparative display mode for the data sheets in the frame. The option is available only if multiple server/link objects have been selected in the Context worksheet and the simulation is not in the *Reset* status

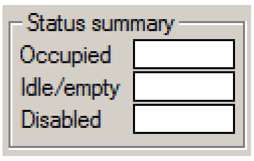
The frame labeled *Component display* controls whether or not local variables and resident attributes are shown on the data sheets for the selected server and link objects.



Local variables
Server/Link property, required for display of local variable data. If this property is not applied to an object, it does not appear in the Variable data sheet, and its local variable values are ignored under application of the Comparative option

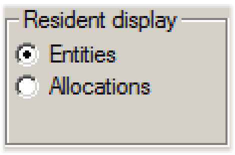
Entity attributes
Server/Link property, required for display of attribute data for resident entities or entities travelling on a link. Attributes are not shown in the Entity data sheet if this check box in unchecked.

Status summary
The right-aligned Status summary frame provides a quick view on server activity. The fields in the frame display the total status times in percentages of the recording time.



Mean values are shown if multiple servers have been selected. The frame is available only if the Servers option is selected and the simulation is not in the *Reset* status.

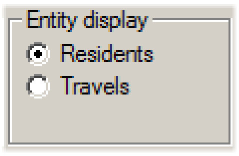
Resident display
This frame determines the data type displayed in the Entity data sheet for server objects.



If the **Entities** option is checked, data are displayed for resident entities of servers. If the **Allocations** option is selected, the number of allocated resources is displayed for all resource servers in visible layers of the project. The frame is available only if the Servers option has been selected, the project has at least one resource server, and the simulation is not in the *Reset* status.

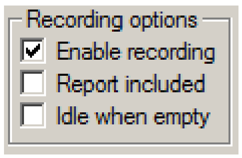
Entity display

This frame determines the entity types displayed in the Entity data sheet for link objects.

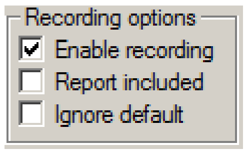

Entity display
(● Residents) ○ Travels

If the **Residents** option is checked, data is displayed for resident entities of the link buffer. If the **Travels** option is selected, data is displayed for entities traveling on links. The frame is available only if the Links option has been selected and the simulation is not in the *Reset* status.

The frame labeled *Recording options* contains three statistics recording options for server and link objects.


Recording options
- [x] Enable recording
- [ ] Report included
- [ ] Idle when empty

If the Variable data sheet or the Entity data sheet has the focus, which is indicated by a different background color of the selected sheet cells, the lower statistics recording option box is replaced by the **Ignore default** option.


Recording options
- [x] Enable recording
- [ ] Report included
- [ ] Ignore default

In that case, the option boxes reflect data recording properties for variable or attribute components that are selected on the data sheet having focus. The options are read-only for attribute components. Statistics recording for entity attributes is controlled exclusively by scripting.

Enable recording

Enables statistics recording for objects. The option is read-only for attribute components. Statistics recording for entity attributes is controlled by the `Recording` scripting procedure.

Report included

Object property that activates object data reporting in an Embedded spreadsheet (See: Data review). The property is only available for objects to which the above-mentioned Enable recording property has been applied. The option is read-only for attribute components, because statistics recording options for entity attributes is controlled by the `RecordingOption` scripting procedure.

Idle when empty

Determines the status tallying method for active servers. By default, a server assumes the *Idle* status when the collection procedure fails verification. (See: Server status). If this property is applied, an active server is considered to be in the *Idle* status whenever it has no residents. The property is only available for server objects and has no effect on passive servers.

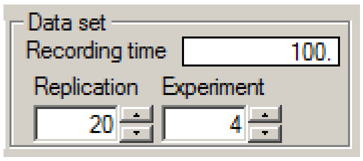
Ignore default

Object property that prevents recording of the Default value as observation for attribute and variable components. The property is only available for objects to which the above-mentioned Enable recording property has been applied. The option is read-only for attribute components, because statistics recording options for entity attributes is controlled by the `RecordingOption` scripting procedure.

If the Statistics option is checked, some other frames appear on the console. These are the below-mentioned Data set frame and two right-aligned frames which offer addition statistics recording options.

Data set

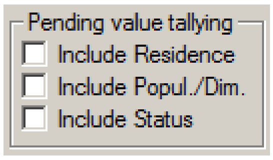
the Data set frame controls which statistics data set is displayed. By default, data are displayed for the current or last completed replication of the current experiment. Data recorded for prior replications can be viewed by entering the corresponding **Replication** and **Experiment** numbers in the text fields, or by using the adjacent up/down-buttons. The **Recording time** field displays the duration of the statistics recording period for the selected replication.


Data set
Recording time 100.
Replication 20
Experiment 4

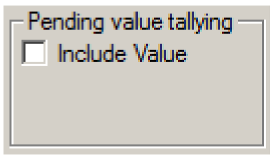
The frame is available only if the Statistics option has been checked and the simulation is not in the *Reset* status. The **Experiments** selection control is available only if the Experiments number has been set to a value greater than *1*.

The right-aligned frames on the Data tab deal with statistics recording. The option boxes in these frames designate object recording options. If the Variable data sheet has the focus, the option boxes designate properties of the variable items selected in the sheet. If the Entity data sheet has the focus, the option boxes designate properties of selected entity attributes on the sheet. The option boxes are read-only for entity attributes, because statistics recording options for entity attributes is controlled by the `RecordingOption` scripting procedure. If the Variable and Entity data sheet neither have the focus, the option boxes designate properties of selected server or link objects, depending on the value of the Servers/Links option.

The frame labeled **Pending value tallying** determines how the Pending value of a recorded property is treated in the evaluation of statistical parameters. By default, statistical parameter calculations only involve recorded observations, thus ignoring the current property value. The option boxes in the frame allow for inclusion of the pending value in parameter calculations for different properties. By application of these options, the present simulation state of the worksheet object is accounted for as an additional observation in parameter evaluation, without being recorded as such.


Pending value tallying
- ☐ Include Residence
- ☐ Include Popul./Dim.
- ☐ Include Status

If the Variable data sheet or the Entity data sheet has the focus, the three option boxes displayed above are replaced by **Include Value** option, which designates tallying properties of the components selected on the data sheet having focus.


Pending value tallying
- ☐ Include Value

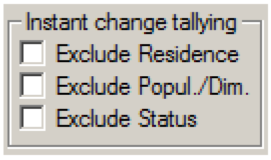
Include residence
Observations of the Residence property record the residence time of each individual entity being removed from storage in a server or link buffer. If this option is applied, the residence times of all remaining residents of the object are included as additional observations in statistical parameter evaluation for the Residence property.

Include Population/Dimension
If this option is applied, the pending value of the Population, Utilization and Dimension properties is included as observation in statistical parameter evaluation for these properties. The option is available for server and link objects, but for link objects it only applies to the Population property, because the Utilization and Dimension properties are not defined for links.

Include Status
If this option is applied, the present duration of the current status (i.e. *Idle*, *Busy*, or *Disabled*) of a server object is included, but not recorded, as observation in statistical parameter evaluation for the Status property of the current status: The option is only available for servers.

Include Value
If this option is applied, the pending value of an attribute or variable component is included as observation in the evaluation of statistical parameters for Value property of components. The option is read-only for attribute components, because statistics recording options for entity attributes is controlled by the `RecordingOption` scripting procedure

The frame labeled *Instant change tallying* determines the statistics recording procedure with regard to instantaneous property changes. The option boxes in the frame allow exclusion of zero duration observations from the statistics recording process for different object properties.



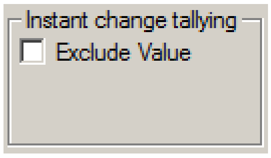
Instant change tallying

☐ Exclude Residence

☐ Exclude Popul./Dim.

☐ Exclude Status

If the Variable data sheet or the Entity data sheet has the focus, the three option boxes in the frame are replaced by the **Exclude Value** option, which designates tallying properties of the components selected on the sheet having focus.



Instant change tallying

☐ Exclude Value

Exclude residence

If this property is applied, zero residence time observations are not recorded for the Residence property.

Exclude Population/Dimension

If this option is applied, state change observations of zero duration are not recorded for the Population, Utilization and Dimension properties. Consequently, multiple identical states, intermitted only by instantaneous changes, form a single continuous observation. The option is available for server and link objects, but for link objects it only applies to the Population property, because the Utilization and Dimension properties are not defined for links.

Exclude Status

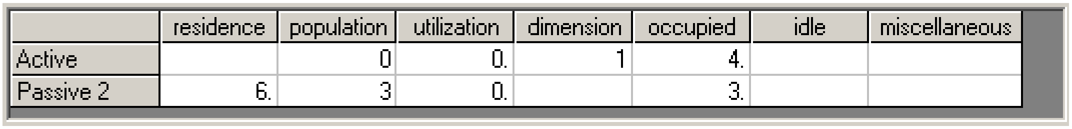
If this property is applied, zero status duration observations are not recorded for the *Idle*, *Busy* and *Disabled* properties. Consequently, multiple identical statuses, intermitted only by instantaneous status changes, form a single continuous observation if this option is applied. The option is only available only for servers.

Exclude value

If this property is applied, variable or attribute value observations of zero duration recorded for components. The option is read-only for attribute components, because statistics recording options for entity attributes is controlled by the `RecordingOption` scripting procedure.

Main data sheet

The Main data sheet displays simulation data for the object type selected by the Servers/Links option. By default, the sheet displays the current value of 2 recordable statistical properties for links, and 5 additional statistical properties for servers.



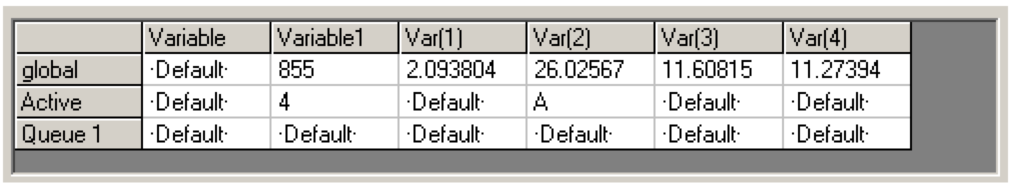
	residence	population	utilization	dimension	occupied	idle	miscellaneous
Active		0	0.	1	4.		
Passive 2	6.	3	0.		3.		

The object properties are indicated in the category row of the sheet. The property values are shown for each selected object on a separate row, with the object name listed in the category column of the data sheet. Other display modes for this sheet are discussed in the topics Display of statistical data and Comparative data display.

Some additional properties of sheet data display are listed in the topic General data sheet properties.

Variable data sheet

The variable data sheet displays simulation data for variable components. By default, the sheet displays the current value of global variables, and, depending on the selected Servers/Links option, also the current value of local variables for either the selected server or link objects.

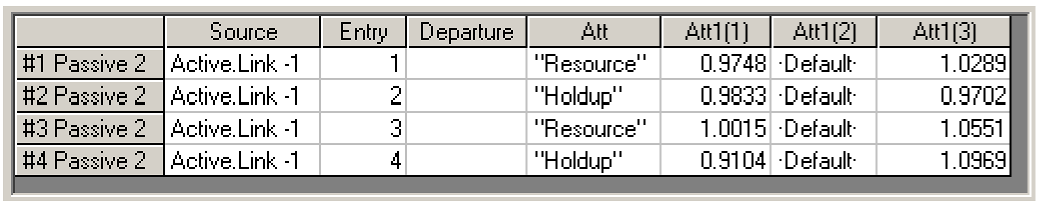


	Variable	Variable1	Var(1)	Var(2)	Var(3)	Var(4)
global	·Default·	855	2.093804	26.02567	11.60815	11.27394
Active	·Default·	4	·Default·	A	·Default·	·Default·
Queue 1	·Default·	·Default·	·Default·	·Default·	·Default·	·Default·

The variable components are organized in columns. The Variable name is indicated in the **category row** of the sheet. The first non-category row displays global variable values. The other rows display local values. Local variable values are displayed for each link or server object on a separate row, with the object name listed in the **category column**. Other display modes for this sheet are discussed in the topics Display of statistical data and Comparative data display. Some additional properties of sheet data display are listed in the topic General data sheet properties.

Entity data sheet

The Entity data sheet displays resource allocation or entity data, including current attribute values. By default, the sheet shows the current value of entity properties and attributes, for the resident entities of all selected server or link objects, depending on the value chosen for the Servers/Links option. Selection of the Allocations option makes the sheet display resource allocation numbers to selected servers. Selection of the Travels option makes the sheet display data for entities traveling on selected links.

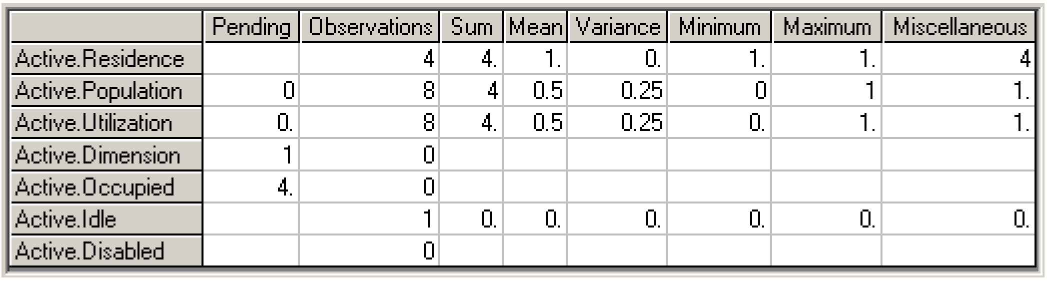


	Source	Entry	Departure	Att	Att1(1)	Att1(2)	Att1(3)
#1 Passive 2	Active.Link -1	1		"Resource"	0.9748	·Default·	1.0289
#2 Passive 2	Active.Link -1	2		"Holdup"	0.9833	·Default·	0.9702
#3 Passive 2	Active.Link -1	3		"Resource"	1.0015	·Default·	1.0551
#4 Passive 2	Active.Link -1	4		"Holdup"	0.9104	·Default·	1.0969

The entity properties and attributes are organized in columns. The values are shown on a separate row for each entity, ordered first by location and then by host. The **category column** lists the entity position (i.e. the storage position number, or travel start sequence number, combined with the number sign #), followed by the host name. The entity sequence number is replaced with the Identifier property, if the **Display identifier** option is checked on the pop-up menu of the sheet, provided the entity identifier is not empty. The category row of the sheet specifies property name and attribute name. The first three data columns display general entity properties. The column labeled **Source** displays the name of the link that created the entity, provided the entity was created by a Tracking link. The column labeled **Entry** displays the simulation time upon storage of the entity in its host. The **Departure** column displays the assigned simulation time for dispatch or expiration of the entity. The sheet cell in this column is left blank if no storage time was assigned. The remaining columns represent attribute values. If the Travels option is selected in the Entity Display frame, the **Entry** and **Departure** columns are replaced by the **Progress** and **Speed** columns respectively. The Progress property represents the fractional distance traveled on the link. The Speed property represents the travel speed as reciprocal value of the travel time. The Progress and Speed property cells are left blank for entities with zero travel time. Other display modes for this sheet are discussed in the topics Display of statistical data and Comparative data display. Some additional properties of sheet data display are listed in the topic General data sheet properties.

Display of statistical data

If the statistics option is selected, the composition of the three data sheets changes to the Statistics display mode, for which the sheets present a set of 8 statistical parameters for recorded property data. The figure below shows an example of the Model data sheet in the statistics display mode for servers.



	Pending	Observations	Sum	Mean	Variance	Minimum	Maximum	Miscellaneous
Active.Residence		4	4.	1.	0.	1.	1.	4
Active.Population	0	8	4	0.5	0.25	0	1	1.
Active.Utilization	0.	8	4.	0.5	0.25	0.	1.	1.
Active.Dimension	1	0						
Active.Occupied	4.	0						
Active.Idle		1	0.	0.	0.	0.	0.	0.
Active.Disabled		0						

The statistical parameters are organized in columns. The parameter name is indicated in the category row of the sheet. The recorded object properties are organized in rows. The Main data sheet has 7 object property rows for each data recording server and 2 object property rows for each data recording link. The Variable and Entity data sheets have only one row for each data recording component. For variables only the value property is recorded and for entities only attribute values are recorded. The category column of the data sheets exhibits the identifier of the default display mode, now followed by the property or component name, separated by a dot.

The Data set frame selects the replication and experiment for data display in the statistics display mode. Entities are identified by the entity Identifier property Recorded entity attribute data for replications other than the current replication are displayed by the Identifier property of the entities in the current replication. (See also: Data storage). In a similar fashion, recorded server, link and variable data for experiments other than the current experiment are displayed by Name property of the object in the current replication.

Comparative data display

By default, data are displayed for each selected server/link object individually, on separate rows of the data sheets. If the Comparative option is checked, data are displayed for all server/link objects jointly on a single sheet row. Data fields that do not have a uniform value for the selected objects are marked with the keyword <*various*>. In the Entity data sheet, entity properties are compared by entity position for all host objects. The category column displays the entity position, followed by the number of entities on that position in the various selected host objects, enclosed in braces.

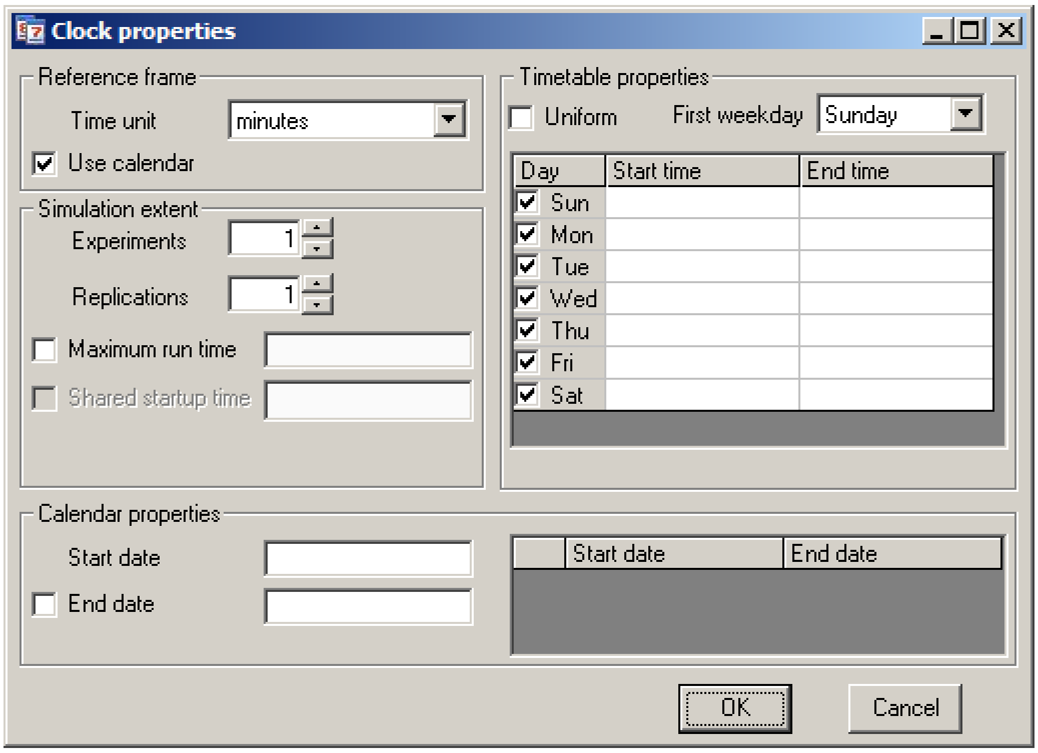
General data sheet properties

- In the simulation *Reset* status the sheets do not show any data in the cells, but do allow creation of data associations. Attribute data associations can only be created in the *Reset* status. An entity must be assigned to the attribute data association by the scripting procedure `AttributeEntity`, for the association to become activated. If the simulation is not in the *Reset* status, and no object has the selected state in the Context worksheet, only the Variable data sheet is shown on the console.

- A cell in the data sheet with a cyan background color indicates a spreadsheet Data association.
- The width of the individual columns of a data sheet can be changed using the standard mouse drag method of the Windows operating system. The column width is reset for all columns in a data sheet by the **Reset column width** command of the pop-up menu. The default column width of the Variable data sheet and the Entity data sheet is set by the **Column width** command of the pop-up menu, provided the statistics option has not been selected.
- An integer number followed by a dot (e.g. 2. as opposed to 2) signifies that the value is of the floating point data type, but rounds off to an integer number.
- Building the data sheets can take a long time to complete if a data sheet has a large number of cells. The process can be interrupted and canceled by holding down the **Esc key** while the mouse pointer appears as hourglass. The compilation of a data sheet can be restarted by double-clicking the sheet.
- The display of components in the Variable data sheet and the Entity data sheet can be disabled for particular link and server objects and for specific attribute and variable components, by using a set of three properties. Variable and attribute components are displayed in the data sheet only if the Display data option has been applied to the component. Local variable values and attributes are displayed for server and link objects only if the Local variables or Entity attribute property has been applied to the object. Furthermore, global variable values are hidden if the Hide when no local data displayed property has been applied to the variable component. And finally, the display of array components can be confined to a specified index range by the Data display bounds property of the component. By combination of these options and properties, the display of attributes and variables may be tailored to suit relevance.

5 Simulation clock

Renque has an internal timing mechanism that can be fully adapted to meet the requirements of the project designer. The timing mechanism of a simulation project is controlled by the Clock properties console, which is activated from the **Clock** item of the Tools menu.



Clock properties

Reference frame
Time unit: minutes
[✓] Use calendar

Simulation extent
Experiments: 1
Replications: 1
[ ] Maximum run time
[ ] Shared startup time

Timetable properties
[ ] Uniform
First weekday: Sunday

Day	Start time	End time
✓ Sun		
✓ Mon		
✓ Tue		
✓ Wed		
✓ Thu		
✓ Fri		
✓ Sat		

Calendar properties
Start date
[ ] End date

	Start date	End date

Operation of the Clock properties console is discussed by the following topics:

- Simulation timing_General_simulation_clock
- Clock properties
- Calendar properties
- Timing unit suffix
- Time display

5.1 Simulation timing

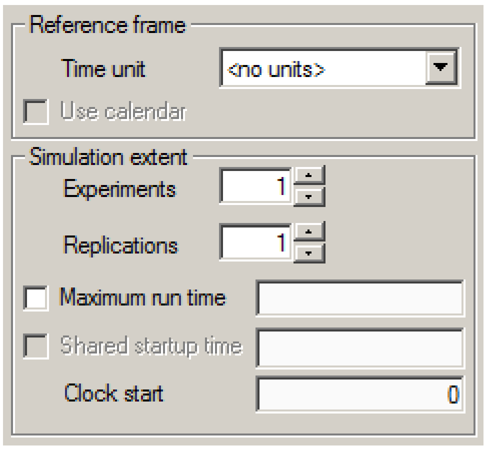
Renque controls the progress of a simulation primarily by the simulation time. The simulation time is continuous and has the value zero when a simulation starts. Renque also has a built-in clock that runs synchronous with the simulation time. By default, the simulation time and clock time are identical, but the clock time is user-adaptable. The main benefit of the clock time is that it enables time-related properties of a project to be specified and displayed in the reference frame of the 12 or 24-hour clock and the Gregorian calendar.

Internally, the clock time is represented by the clock parameter. This parameter is a floating-point number of which the significance depends on the Clock properties applied. The internal clock parameter can be referenced directly or formatted in a user-friendly style. By default, the clock parameter is equal to the sum of the simulation time and the Clock start time. If a Time unit has been specified, the clock parameter is a fractional number, representing time in the range 0:00:00 to 23:59:59, such that midnight is represented by the value 0 and noon is represented by the value 0.5. If the Use Calendar option is applied, the clock parameter also has an integer part, which represents the calendar date in the range January 1, 100 to December 31, 9999, with the value 0 representing December 30, 1899.

The simulation time and clock time may both be addressed by Time display format strings, by schedule components, graph servers, and by scripting Clock procedures. The clock time is usually specified and displayed in a format in accordance with the regional system settings. The unformatted clock parameter can be referenced by the `ClockTime` scripting function.

5.2 Clock properties

The Clock properties console manages all properties of the timing mechanism of a simulation project. The controls on the window are organized in frames. Some frames on the window are hidden if they are not relevant to the values selected for the Time unit combo box and Use calendar check box. The default appearance of the console is shown in the figure below.


Reference frame
Time unit: <no units>
☐ Use calendar
Simulation extent
Experiments: 1
Replications: 1
☐ Maximum run time
☐ Shared startup time
Clock start: 0

Time unit
Defines the physical time unit applied to the clock time. For the default value <*no units*> the clock time is dimensionless.

Use calendar
Selects the Gregorian calendar as reference frame for the simulation clock. If checked, the Calendar properties frame is shown. The check box is not available if the <*no units*> value has been selected in the above-mentioned Time unit control.

Experiments
Sets the number of experiments for a simulation run. The maximum number of experiments is 32000.

Replications
Sets the number of replications for a simulation run. The maximum number of replications is 32000.

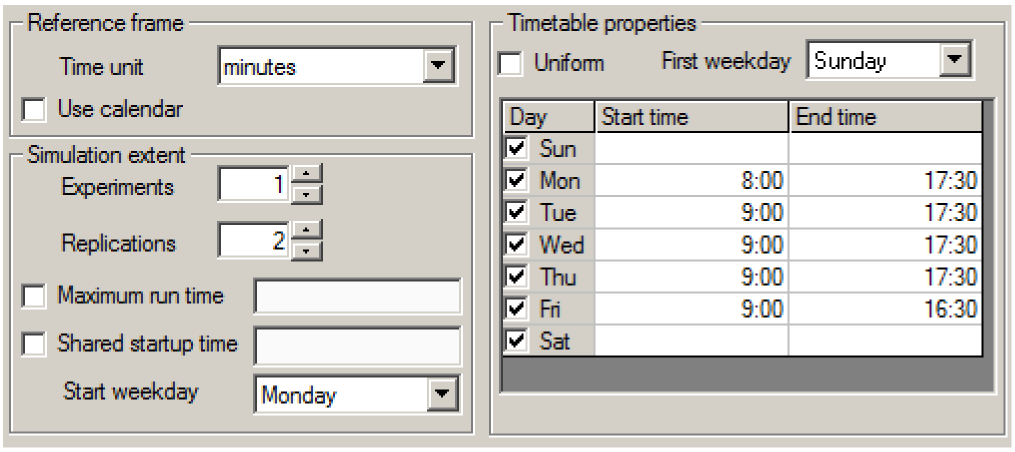
Maximum run time
Enables a specified maximum run time for all simulation replications. The run time is expressed in the selected Time unit. The associated text field accepts any positive floating-point number.

Shared startup time
Enables a shared startup simulation state for simulation replications. If applied, the simulation state at the specified startup time of the first replication of an experiment is used as initial state for all subsequent replications. Application of this property may radically reduce computation times for simulations which quite slowly reach a steady state. The shared startup state always incorporates a statistical data Statistics reset. The startup time is expressed in the Time unit selected. The associated text field accepts any positive floating-point number. The property is not applicable if the number of replications is 1.

Clock start

Defines the start value for the clock time. The associated text field accepts any floating-point number. Only available if the *<no units>* value been selected in the Time unit combo box

If a time unit has been selected in the Time unit combo box, the clock time is dimensional, which permits expression of the clock time in the 12 or 24-hour clock system, and distinction between weekdays. In the dimensional clock time reference, the Timetable properties frame is shown and the **Clock start** text field in the Simulation extent frame is replaced by the **Start weekday** combo box. The Timetable properties frame defines the master timetable for the simulation clock. It is also used to view and edit Calendar timetables.



Time unit: minutes
Use calendar: ☐
Experiments: 1
Replications: 2
Maximum run time: ☐
Shared startup time: ☐
Start weekday: Monday
Uniform: ☐
First weekday: Sunday

Day	Start time	End time
✓ Sun		
✓ Mon	8:00	17:30
✓ Tue	9:00	17:30
✓ Wed	9:00	17:30
✓ Thu	9:00	17:30
✓ Fri	9:00	16:30
✓ Sat		

Start weekday

Selects a weekday as start value for the clock time. Not available if the Use calendar box has been checked.

Uniform

If this timetable property is checked, the master timetable is identical for all weekdays, and the below-mentioned Timetable grid has only one row.

First weekday

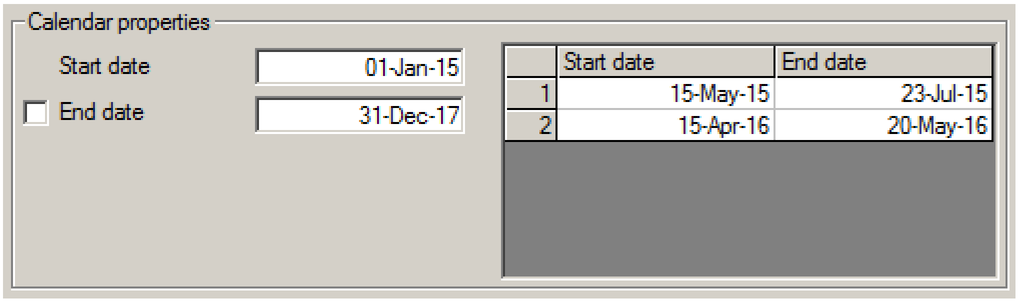
This simulation clock property determines the week day order in the Timetable grid. If the above-mentioned **Uniform** option is applied, the property determines the week day row to be applied to the uniform timetable. It also affects the result of some placeholder strings in time display and some clock procedures in scripting, by the count order of weekdays. The day selected in the combo box is defined as number 1.

Timetable grid

Defines the master timetable for the clock time. The timetable grid has a row for every day of the week. The first grid column specifies the Weekday**,** with a check box to enable/disable the corresponding day in the timetable. The other columns define the **Start time** and **End time** of day segments in column pairs. By default, the grid has a single column pair. Column pairs can be added and deleted using the **pop-up menu** of the grid. A blank **Start time** cell of a day segment signifies the day start time (0:00:00). A blank **End time** cell signifies the day end time (24:00:00). A day segment is invalid if it has a higher start time value than the end time value, or a start time value smaller than the end time value of the previous day segment. Invalid day segments are indicated in a red text color in the grid. The clock schedule stores the first segment and only higher day segments that form a directly following continuous chain of valid segments. A week day with an invalid first day segment is skipped in the simulation.

5.3 Calendar properties

If the Use Calendar box is checked the simulation clock addresses the built-in Gregorian calendar. The calendar properties are displayed in the Calendar properties frame.


Calendar properties

Start date	01-Jan-15
☐ End date	31-Dec-17

	Start date	End date
1	15-May-15	23-Jul-15
2	15-Apr-16	20-May-16

.

Start date
Determines the start date of the simulation clock.

End date
Enables a specified end date of the simulation clock. Can be used together with the Maximum run time property.

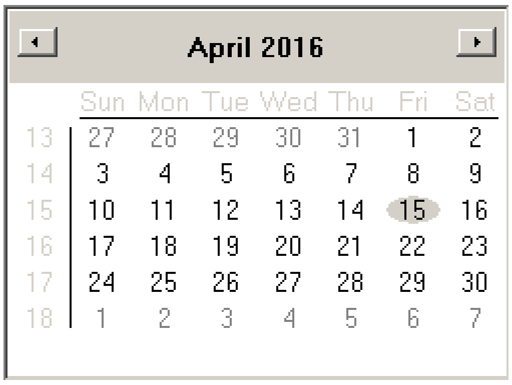
Calendar timetable list
The Calendar timetable list defines calendar timetables for the clock time. A calendar timetable applies a particular timetable to the simulation clock for a specified calendar period, which temporarily overrides the master timetable of the simulation clock. Calendar timetables can be added and deleted by commands of the **pop-up menu of the list**.

The timetable list grid has three columns. The category column displays a sequence number. The second and third columns define respectively the **Start date** and **End date** of the calendar timetable. The dates are assigned by typing a date value in the grid cell in the system’s date format, or by using the Date selection tool. A blank grid cell signifies the current system date. A calendar timetable is invalid if it has a start date later than its end date, or a start date equal to or sooner than the end date of the previous item. Invalid calendar timetables are displayed in an alternative text color, and ignored in the simulation.

The Timetable grid displays the composition of the timetable for the selected item in the Calendar timetable list. The grid may be edited in the same manner as for the master timetable to change the properties of the selected Calendar timetable.

Date selection tool

The data selection tool appears after double-clicking on one of the control items on the Calendar properties frame. It displays a graphical calendar representation for a single month of a year, including weekdays and week numbers.



April 2016

	Sun	Mon	Tue	Wed	Thu	Fri	Sat
13	27	28	29	30	31	1	2
14	3	4	5	6	7	8	9
15	10	11	12	13	14	15	16
16	17	18	19	20	21	22	23
17	24	25	26	27	28	29	30
18	1	2	3	4	5	6	7

The display month and year can be altered by buttons at the top of the calendar. A date value is assigned to the source control by double-clicking on a day number calendar.

5.4 Timing unit suffix

In the simulation time reference, object timing properties are expressed in the selected Time unit value of the simulation project. If a non-dimensionless Time unit is assigned, time values may be entered into property text fields in a different unit than the specified simulation time unit, by using a suffix character. For example, entering *2h* converts to the value 120 if the assigned Time unit is *minute*.

Suffix characters

- l (milliseconds)
- s (seconds)
- m (minutes)
- h (hours)
- d (days)
- w (weeks).

5.5 Time display

The time progress of the simulation is displayed in the right-most panel of the Status bar. Time can also be displayed on graph servers. The time is display format is controlled by a user-defined format string. Renque has a set of placeholder strings to format the simulation time and the clock time, which enable time display format in any desirable format. Any combination of placeholder strings can be used in the time display format string.

As an example of the use of placeholder strings for time display, consider a simulation run with the following clock properties:

Use Calendar:	Yes
Simulation start:	Wednesday March 5, 1980
Wednesday timetable:	02.00 to 18.00 hrs
Time unit:	minutes

At 4:10:22 am on the simulation start date, the following time representations are obtained:

simtime	850.366608
#.0	850.4
General Date	*3*/5/1980 4:10:22 AM
Hh:Nn:Ss	16:10:22
dddd, h:mm AM/PM	Wednesday, 4:10 PM

The default time format string is the placeholder string *simtime*, which displays the simulation time as floating point number. The placeholder string *T* displays the clock time in the standard system format. The format string is edited by clicking on the time display panel of the Status bar.

For graph servers with Style value *Text*, the time format is specified in the Content text field on the Content tab page. For graph servers with Style value *Time series line chart*, the time format is specified in the Format field of the Display style frame.

The section Formatting by placeholder string presents a complete list of the placeholder strings recognized by Renque. Characters included in the format string that do not represent a placeholder string are displayed literally. Placeholder strings are displayed literally if enclosed between brackets or preceded by a backslash character.

Depending on your system’s regional settings, the separator symbols for decimal, thousand, date and time may differ from the English language standard (respectively dot, comma, slash and colon). Renque only recognizes the English standard separator symbols as placeholder strings. However the actual display of numbers, time values and dates is consistent with the regional settings.

6 Simulation operation

The principal purpose of the compilation of a simulation project is, of course, to run simulations, generate simulation data and analyze the results. This section covers the operation of simulation models by the following topics:

- Running simulations
- Simulation data recording
- Animation
- Charting

6.1 Running simulations

Simulation operation in Renque is controlled primarily by the **Reset**, **Restart** and **Pause** items of the Run Menu. These items have functions very similar to their equivalents on any common media player. Renque also offers additional methods to control a simulation run. This topic discusses the various ways by which a user can control the extend of a simulation run and interact with the process through the menu.

Experiments and Replications

Some statistical data analysis methods in discrete event simulation use multiple equivalent simulations with different random numbers. In Renque such equivalent simulations are known as replications. Replications are individual simulations, starting from the *Reset* status, with a unique seed value for the random number generator. As a result, each replication is run with a different set of random numbers, and yields different results. The number of replications to be performed in a simulation run is set by the Replications item of the Clock properties console. The Statistical analysis tool provides a method to estimate a range for the theoretical average value of simulation data parameters for an unlimited number of replications.

Renque also offers the possibility to execute multiple experiments for a simulation run, with each experiment comprising multiple replications. By default, the experiments are identical, but they may be customized manually or automatically by the *Simulation state* Method of schedule components. Simulation experiments are particularly useful for parameter sensitivity analysis and to solve optimization problems. The number of experiments to be performed in a simulation is set by the Experiments item of the Clock properties console. The Statistical analysis tool provides a method to test the hypothesis that two experiments yield a different value for a specified simulation data parameter.

Recorded statistical data can be displayed for any replication of any experiment on by the available data presentation methods.

Simulation status

The simulation status of a project can have one of four possible values: *Reset*, *Running*, *Paused* and *Stopped.* A simulation starts from the *Reset* status and has the *Running* status when in operation. In the *Running* status, the simulation may be suspended temporarily by the user in order to review intermittent results. The simulation assumes the *Paused* status when an incomplete replication is suspended. When operation is suspended while the current replication has been completed, the simulation assumes *Stopped* status.

Mutations made to a project while the simulation is in the *Paused* status are applied when the simulation is resumed, generally without the requirement of a simulation reset, although some changes may cause a server interrupt when the simulation is resumed.

Replication termination

By default, a simulation replication continues to run until there are no events left in the Event calendar. There are several methods to force termination of a replication. The **End replication** command of the Run Menu terminates a replication while the simulation is in the *Paused* status. The Maximum run time and the End date_Calendar_termination items in the Clock properties console allow replications to be terminated at a predetermined simulation time. The script procedure

`ReplicationTerminate` terminates the current replication by execution of a schedule or incident script.

Simulation run control

The normal scenario of a simulation run comprises the following stages. The simulation starts from the *Reset* status with the first replication of the first experiment, and enters the *Running* status. When the replication ends, the next replication starts immediately. If all replications of an experiment have been performed, the simulation continues with the first replication of the next experiment. When all experiments have been concluded, the simulation run ends in the *Stopped* status. At that point the simulation cannot be resumed, unless the number of experiments or replications is increased in the Clock properties console.

The Run Menu offers various possibilities to interact with the flow of a simulation run. The Run menu has three controls that are also available as Toolbar button:

• **Reset**	Resets the simulation, discarding all data.
• **Restart**	Starts a simulation from the *Reset* status or restarts the current experiment from the *Paused* status, discarding all experiment data.
• **Pause**	Suspends or resumes the simulation.

The other commands in the Run menu are:

• **End replication**	Terminates the current replication in the *Paused* status.
• **Run experiment**	Starts or resumes the simulation and suspends the simulation when the current experiment is completed.
• **Reset experiment**	Resets the current experiment from the *Paused* status, discarding all experiment data.

The last two items are available only if the number of experiments is set to a value greater than 1.

Stepwise execution of events is performed using the Step button of the event viewer utility. The scripting command `Pause` pauses a simulation in the Running status.

6.2 Simulation data recording

Renque can record various object and component properties during a simulation run and calculate statistical parameters for the recorded data set. The recorded property values are known as observations.

Statistical properties

The recorded properties for link and server objects are:

• **Residence**	Entity storage time in the object.
• **Population**	Number of entities stored in the object.

For servers there is a set of five additional recorded object properties:

• **Utilization**	Ratio of Population and server Capacity.
• **Dimension**	Server Capacity.
• **Occupied**	Duration of the Occupied status.
• **Idle**	Duration of the Empty/idle status.
• **Disabled**	Duration of the *Disabled* status.

Variable and attribute components have only one recorded property:

• **Value**	Variable value or entity attribute value.

The *Current value* is the property value in the present simulation state. For the Residence property the current value represents the sum of the residence times of all entities presently stored in the server or link buffer. The current Residence value is *Void* if the object has no residents. The current Utilization value is defined as zero for the *Void* server Capacity. The current value of the Occupied, Idle and Disabled properties is *Void* if the property doesn't represent the current server status.

Only numerical values are recorded in the statistics recording process. Thus, the *Void* server capacity is not recorded as a Dimension observation, nor are non-numerical variable and attribute value observations.

The Population, Utilization, Dimension and Value properties are recorded when the property value is about to change. The Occupied, Idle and Disabled properties are recorded when the corresponding server status ends. Recording of the Residence property records the residence time of single entities when they are removed from storage in a server or a link buffer.

For Resource servers, the Population property denotes the number of available resources and the Residence property is undefined. In addition, the Utilization property is defined as 1 minus the ratio of Population and Capacity.

Statistical parameters

Renque can calculate a number of statistical parameters for the recorded observations. These parameters are

• **Pending**	Current property value pending recording.
• **Observations**	Number of observations: N.
• **Sum**	Sum of the observations Σ X.
• **Mean**	Algebraic mean of the observations: $\mu = \Sigma X / N$.
• **Variance**	Variance of the observations: $\Sigma (X - \mu)^2 / N$.
• **Minimum**	Minimum value X of the observations
• **Maximum**	Maximum value X of the observations.

All recorded property data have one additional parameter, which differs between the recorded properties as follows:

• **Arrivals**	Number of entity arrivals for the Residence property:
• **Time-averaged**	Time averaged value: Σ (X·dt) / Σ dt, where dt is duration of observation X for the Population, Utilization and Dimension object properties and the Value property of variable and attribute components:
• **Fraction**	Fraction of the total status time Σ X to the recording time for the Occupied, Idle/empty and Disabled properties.

The Pending parameter signifies the pending observation, i.e. the value to be recorded if observation recording were imminent. The pending value is equal to the current value if the current value is numerical, and Instant change tallying exclusion is not applied.

Recording properties

Statistics recording is optional for all objects and components. For servers, links and variables recording is activated by the Enable recording item of the Object properties console. Data recording is enabled by default for servers. Statistics recording for attribute components is performed for individual entities. The scripting procedure `Recording` enables attribute recording for an entity.

There are a number of options available for the data recording method and parameter evaluation procedure. These options are set on the Data tab of the Object properties console for servers, links and variables. The recording options for entity attributes are controlled by the scripting procedure `RecordingOption`.

Statistics recording starts when a simulation replication starts, and continues until the replication ends. The recording time period can be trimmed by the `ResetStatistics` scripting procedure, which discards all recorded observations and recommences the recording process.

Data storage

Recorded statistical data for server and link objects, including local variable data, are stored in the object. Global variable and attribute data are stored in the component object. Recorded data are stored in this manner for all replications of the current simulation experiment. Upon completion of an experiment, all recorded statistical data stored in server, link and component objects are detached from the object, and transferred to a location where data are stored by object name. Comparison of object data between experiments must therefore be preformed by object name. For entity attribute data, the reference to the entity is maintained by the Identifier property of the entity. The actual entity object cannot be used as reference because entities are deleted when a new replication starts. As a result, comparison of entity attribute data between replications, such as by the Statistical analysis tool are performed on the basis of entity identifiers. The project designer needs to make sure that identical object names in different experiments and identical entity identifiers in different replications represent the intended artifact in the project.

Data review

Simulation data can be viewed in different ways. The Data tab of the Object properties console represents the main method. This feature allows for examination of all available data for server and link objects, as well as variable and attribute values, and properties of server and link buffer resident entities.

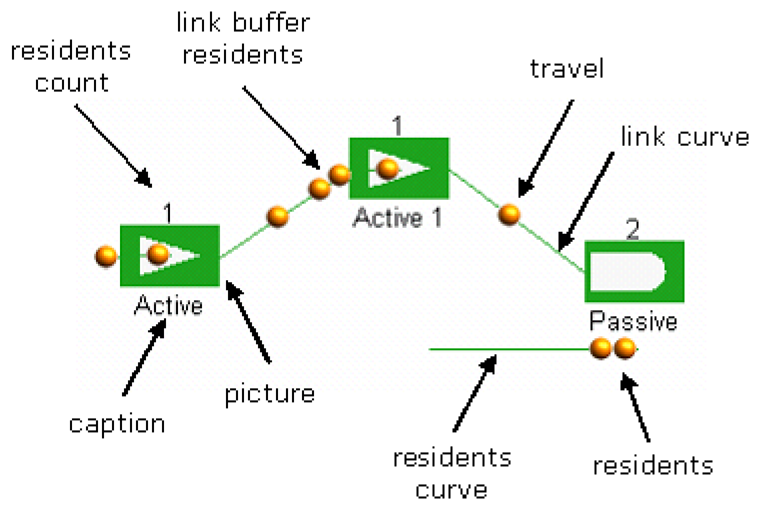
Simulation data can also be written to the embedded workbook. The Data export feature writes recorded statistics to a specified Excel spreadsheet. Data can also be written to designated cells in any spreadsheet of the embedded workbook by data associations. Furthermore, simulation data can be displayed in various ways in graph servers.

All recorded statistics are accessible by scripting through statistical functions of server and link objects, and variable and attribute components.

6.3 Animation

Animation in Renque has a dual purpose. Animation can be employed as visual debugging instrument and as presentation support. As demonstrated in the figure, the following server and link elements are displayed in animation:

- Server picture
- Server caption
- Server residents
- Server residents count
- Server residents curve
- Link curve
- Link buffer residents
- Link travel



The animation display characteristics of individual server objects are controlled on the Display tab of the Object properties console, and for links on link Display tab. Besides some properties that control specific animation functions, all items marked in the figure can be hidden using the controls on the Display tab pages. Furthermore, each server object can be assigned a specific picture component and the font applied to the caption and resident count display of servers can be modified.

Entity travel

Entity travel on links is fully animated. The animation speed is controlled by the Animation speed slider item on the Menu bar. Travels on links with an assigned zero Travel time property are animated using a uniform apparent travel speed. When an entity travel with zero timing is animated, there is no advance of the simulation time and all entities traveling with non-zero timing are static. The apparent travel time applied is adjustable by **Zero timing** item of the Animation preferences.

Resident entities

Entities stored in a link buffer or in a server are painted as a queue on the link and residents curve respectively. The spacing between the entities is determined by the Entity spacing property of the server or link. The number of entities displayed is limited by the length of the curve. The location of the buffer on a link is determined by the Upstream buffering property of the link. On an upstream link, the buffer is located on the upstream side of the link, as the property name suggests, otherwise entities are buffered at the downstream side of the link. The Upstream buffering property is reflected by the location and expansion direction of the queue on the curve.

Animation display order

Servers are painted on the Worksheet in back-to-front z-order, such that server pictures with higher z-order level can partly or completely cover the picture, caption and resident count of servers with lower z-order level. Newly created servers are placed on top of existing servers. The z-order level of existing servers can be modified by the **Bring to Front** and **Send to back** items of the Format Menu. Resident curves and link curves are displayed on top of the highest server z-order level. Resident curves are painted in the same order as servers. Link curves are painted on top of the resident curves. The paint order of link curves cannot be changed.

During a simulation, curves and server pictures are painted on the Worksheet at a static background level, whereas entity icons, server caption and resident counters are painted on a more volatile dynamic level. Entity transformations and server caption modifications are animated with high speed at the dynamic level. In contrast, changes made by the `Positionshift` or `Picture` scripting procedures of a server object require rendering of the background level, which presses more heavily on the computational resources of the system.

7 Scripting

Scripts are short commands in the *Microsoft Visual Basic Script* language (VBScript). In Renque they are used to accomplish particularities in the behavior of the project at a level of detail that cannot be reached by adjustment of the standard object properties. Scripts are applied to server or link objects in response to specific simulation incidents and to schedule components.

One does not require extensive knowledge of Visual Basic Scripting nor does one need to be familiar with programming techniques to apply scripts to a Renque project. The following script examples are typical and introduce the syntax style used.

```
Active.Timing = 6.2
```
sets the Timing property of a server named Active equal to 6.2

```
Variable = Variable + 1
```
increments the global value of the variable named *Variable*

```
if Variable = 1 then Active.Capacity = 5
```
sets the Capacity property of server Active to the value 5 only if the value of *Variable* equals unity

General information on the *Visual Basic Script* language is available on this web link: Microsoft Visual Basic scripting guide. The topics Renque syntax rules, Script editing and Runtime errors discuss how to use Visual Basic scripting in the Renque environment. Scripting procedures defined exclusively for Renque are discussed in the following topics:

- Global procedures
- Entity procedures
- Server procedures
- Link procedures
- Component procedures
- Clock procedures
- Shared procedures

7.1 Renque syntax rules

A Renque script does not allow multiple VBscript statements separated by colons or multiple lines. This policy places considerable restrictions on the set of language features that yield valid scripting code. Many VBscript constructions commonly used in VBScript applications, such as For...Next and Do...Loop combinations cannot be used in Renque. Other functions not permitted in Renque scripting include the CreateObject and GetObject functions which, among other things, excludes file manipulation.

Keywords

The following VBscript keywords have a particular significance in Renque scripting:

Empty	In VBscript the *Empty* keyword is used to express the value of a non-initialized variable. In Renque it is used to clear variable or attribute component data from memory and reactivate the default value.
Null, Nothing	These keywords can be assigned to variable or attribute component values but have no meaning in the Renque environment. An attempt to assign these keywords to object properties will usually result into a scripting error being raised.
True, False	Are used in Renque to represent Boolean property values.

Object references

Scripts can be used to retrieve and modify object properties, and to impose certain object transformations. All server and component objects can be referenced in scripts by their Name property. This reference instruction is object-oriented: If the Name property of an object is changed all name references to that object in scripts change accordingly.

As an alternative to referencing by name, servers and components can be referenced by an array expression. For example, the server or component named *Element 1* may be referenced as `Element(1)`. The index argument 1 in this expression type is not restricted to numbers. Any script expression may be used on the index placeholder. Thus, the syntax style `Element(X)` refers to the *Element 1* if X is a script expression that evaluates to 1. Except for variable and attribute components, the array referencing method is not object-oriented. The `Element(1)` reference is lost when the Name property of the *Element 1* object is changed.

Local variables are addressed by combination of an object reference and variable name separated by a dot: For example:

`Active.Variable = 3` or `Variable.Active = 3`
assigns the value *3* to the variable named *Variable* of the server named *Active*.

Assembly references

In contrast with other Renque object types, link and entity objects are not referenced by name. Links are usually referenced on the basis of their connectivity to servers by a set of instructions, referred to as Assembly. Renque assemblies are objects representing an assortment of related links or entities. For example:

```
ServerName.CollectingLinks.Item(1)
```
references the top collecting link of the server named *ServerName.* The `CollectingLinks` procedure returns an assembly of collecting links of the server,

and the Item function returns a link object in the assembly. In a similar way, entities are usually referenced by a server or a link assembly that present the residents of the object, in order of arrival For example:

```
ServerName.Residents.Item(2)
```

returns the entity stored in the server, with the second earliest arrival time. The `Residents` procedure returns an assembly that contains all resident entities of the server.

Implicit object references

The script object can be referenced implicitly by omission of the object name. For example, the two scripts

`Active.Timing = 6.2` and `.Timing = 6.2`

are equivalent if server Active is the script object. Similarly, for a schedule component named *Schedule,* the scripts

`Schedule.ColumnIndex` and `.ColumnIndex`

are equivalent if the schedule is the script object.

The script entity is referenced implicitly by omission of the reference altogether. For example:

`ScriptEntity.Icon = BlueBall` and `Icon = BlueBall`

are equivalent.

Using object references

Attribute, variable and distribution components can be assigned to properties by scripting. For example:

```
Active.Timing = Variable1
```

assigns the component *Variable1* to the Timing property of server *Active*.

The component procedure Eval can be used to specifically assign the value of a component. For example:

```
Active.Timing = Variable1.Eval
```

assigns the value of component *Variable1* to the Timing property of the server *Active*.

Server and link objects and distribution components can be assigned to attribute and variable components:

```
Variable = Active
```

stores the server named *Active* as object in the variable named *Variable*.

When comparing objects, for example in an if...then statement, the scripting comparison operator `is` must be used instead of the equal sign operator. Thus:

```
if ServerName.Timing is VariableName then ...
```

returns *True* only if the component *VariableName* has been assigned to the Timing property of the server named *ServerName*. On the other hand, the script

```
if ServerName.Timing = VariableName then ...
```

returns *True* if the Timing property has the same numerical value as the variable component or if the Timing property has been assigned a component that evaluates to the same value.

Special objects

The Renque **Void** object is generally used to indicate an ineffectiveness, absence or omission, such as for the Capacity property of servers with unlimited storage capacity for entities. The *Void* object is referenced explicitly by the scripting instruction `Void`. A number of Renque procedures make use of the Void object as a return value or to assign an object property. The `IsVoid` function may be used to verify if an expression has the value *Void.*

The properties of a script being executed can be identified by two objects. A script is executed either as a result of a scripting incident or by a schedule line. The script owner, which is the object that induces execution of the script, is referred to as the **script object**. The script object of an incident script is the server or link object that generated the incident. The script object of a schedule script is the schedule component. The script object is referenced by the scripting instruction `ScriptObject`. Similarly, the **script entity** is the entity that causes execution of the script. It is referenced by the scripting instruction `ScriptEntity`.

The simulation clock has a variety of scripting procedures that allow retrieving information on the simulation progress. The **simulation clock** is referenced by the scripting instruction `Clock`.

Renque-specific scripting procedures

Besides the standard elements of the VBscript language, Renque offers an assortment of scripting procedures that provide access to the properties of a simulation project and its elements. The procedures names typically match the property names displayed in the user interface, such as the Timing property used earlier in the examples of this topic.

In accordance with the syntax rules of the VBScript language, the general form of a Renque procedure is given by:

```
ProcedureName[(argument1,[argument2,[...]])]
```

A procedure may or may not require one or more arguments, separated by commas. The square brackets in this definition indicate optional arguments. A default value is used if an optional argument is omitted in a procedure call.

The VBScript language has three procedures types.
1. The Statement procedure type, which does not have a return value
2. The Function procedure type, which does have a return value
3. The Property procedure type, which can be used to retrieve and assign data.

The code structure of three procedure types is as follows:
```
StatementName[(…)]
… = FunctionName[(…)]
PropertyName[(…)] = …    and    … = PropertyName[(…)]
```

Renque procedure generally have a specific object type context, which is determined by the object type to which the procedure is applicable. The `Timing` procedure, for instance, is a server procedure because it is defined only for servers. Some procedures have a global context, which means that they are not applied to an object, and some procedures have a shared object context.

All Renque procedures are discussed in the remaining topics of this section, categorized by object context. For each procedure the procedure name is specified, followed by the procedure arguments enclosed in parenthesis. Where applicable, the default value of optional arguments is indicated. The procedure descriptions also specify the procedure type (Statement, Function or Property), together with the return value type for Function and Property procedures.

The Renque procedure topics are:
- Global procedures
- Entity procedures
- Server procedures
- Link procedures
- Component procedures
- Clock procedures

A complete list of the available Renque procedures in alphabetical order is given in the Reference section.

7.2 Script editing

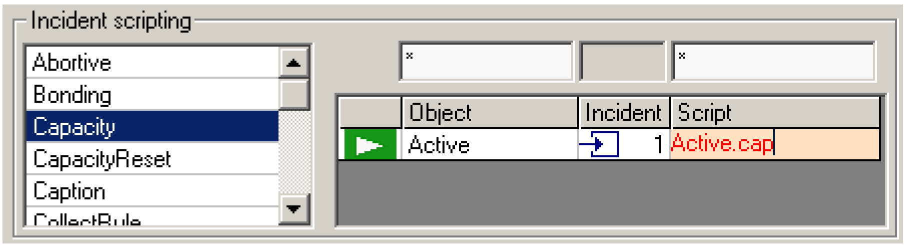
Renque scripts are edited directly in the cells of the schedule grid and incident grid. The script edit mode can be activated by double clicking a cell, by pressing a key while a cell is selected, or by dragging an object into a cell. The edit mode is indicated by a alternate cell back color and by the appearance of the an alternative script editing field at the top of the window, below the tab strip. This field has the same content as the cell being edited. However, it has a non-proportional font and may have multiple lines, which helps editing lengthy or complicated scripts.

The syntax of a script being edited is checked every time it changes. Valid scripts are shown in the standard black color. If the script contains a syntax error, it is shown in the color red, and a status bar on the bottom edge of the Object properties console displays a message describing the error. A complete guide to the *Microsoft Visual Basic Script* language is available on Microsoft's website: Microsoft Visual Basic scripting guide.

The edit mode is terminated and changes made to a script are saved by pressing the **Enter key**, pressing the **Up** or **Down arrow key** (except for the alternative script edit field), or by shifting the focus to another grid cell or another control on the window. Pressing the **Esc key** terminates the edit mode without saving changes.

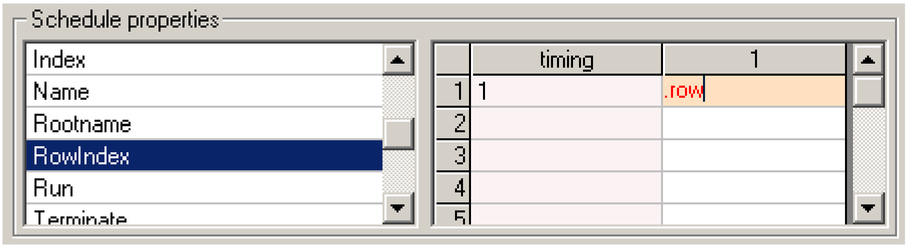
Automatic code completion

Renque makes writing script code easier with a feature known as *Automatic code completion,* which can automatically fill in procedure names in edited scripts. As you enter scripting code, the **Procedure name list** is displayed if the caret moves to a suitable insertion point, such as behind a dot character. The list presents all Renque procedure names appropriate for the insertion point. Type in the first few letters of the procedure name and the matching name will be selected from the list. Pressing the **Enter key** or the **Space bar** will complete the typing for you, by replacing the text on the insertion point with the name of the selected procedure in the list.



	Object	Incident	Script
	Active	1	Active.cap

For schedule script editing, the **Procedure name list** is positioned on top of the schedule controls adjacent to the schedule grid.



	timing	1
1	1	.row
2		
3		
4		
5		

The Automatic code completion feature is also helpful when you aren't sure which procedure names are available for a given object type. The appropriate procedure names are determined automatically by the composition of the scripting code preceding the caret position. Global procedures are not displayed automatically. If the caret is on a position befitting a global procedure, the global procedure list is shown when **Space bar** is pressed while holding down the **Ctrl** key.

While the procedure list is visible, the selected procedure name can be changed with the **Up/Down**, **Page Up/Page Down** navigation keys. Hold down the **Alt key** to retain the normal function of these keys.

When the caret moves to a position unsuitable for insertion of a procedure name automatic code completion is deactivated and the procedure list is hidden. Pressing the **Esc key** also deactivates automatic code completion until the caret is again placed on a suitable insertion point. The Automatic code completion feature may be disabled completely by the **Automatic code completion** item of the Scripting preferences.

Renque also indicates applicable procedure arguments when a script is being edited. If the caret is moved to a position to the right of an opening parenthesis punctuation character, which represents an insertion point for an argument of a Renque procedure call, a third pane becomes visible on a **status bar** at the bottom of the window. This pane shows the argument names of the procedure, with the argument name at the insertion position highlighted by enclosure in braces. An identifier symbol precedes the argument name to indicate the required data type for the argument. The identifier symbols used are: # (numerical value), $ (string value), * (argument requires an object), and ~ (argument requires a script snippet).

7.3 Runtime errors

A script that contains a syntax error is said to be invalid. Invalid scripts are not executed in a simulation run. Valid scripts can still cause errors in a simulation run for a variety of reasons. Such errors are known as Runtime errors. Runtime errors do not cause a simulation run to be stopped. If a runtime error occurs, the execution of the script causing the error is aborted, but the simulation will continue as normal.

Error messages

All runtime errors create an entry in the error message list of the Runtime error viewer, for review by the project designer. The list may contain general Visual basic error messages and Renque procedure error messages. The Renque scripting procedure name list presents a complete list of Renque error messages.

7.4 Global procedures

Global Renque procedures are called without reference to an object. The global procedures group has three functions that return a specific object and a set of procedures with miscellaneous purposes. The available global procedures are:

Object-referencing procedures

`ScriptObject`
Function (Object). References the script object. The script object of incident scripts is the server or link object that generated the incident. The script object of a schedule script is the schedule component.

`ScriptEntity`
Function(Object). References the script entity. The script entity is the entity that causes execution of the script. The function returns *Void* for schedule scripts and for Select collect incident scripts.

`Clock`
Function(Object). References the simulation clock. Required to call Clock procedures.

`Void`
Function (Object). References the Void object.

Assembly-related procedures

`Member`
Function (Object). References the assembly member of the current loop in the assembly procedures `Count`, `Sweep` and `Exclude`. Returns *Void* when called outside the *Criterion* argument of the Count and Exclude procedures or the *Operation* argument of the Sweep procedure. For a Count or Exclude procedure nested inside the *Operation* argument of a sweep procedure, the *SweepMember* keyword can be used to reference the assembly member of the current sweep loop.

Miscellaneous procedures

`CellValue(WksName, RowNumber, ColNumber)`
Property(Variant). Returns or writes a value to a spreadsheet cell of the embedded workbook. The argument *WksName* is a string that represents the name of the spreadsheet in the workbook. The arguments *RowNumber* and *ColNumber* are integer numbers representing the cell row and column numbers respectively.

`Pause`
Statement. Pauses the simulation after execution of the current calendar event.

`Freeze(mSecs)`
Statement. Suspends the simulation for a number of milliseconds real time equal to the argument *mSecs*. If the value –1 is passed for the argument *mSecs*, the simulation is suspended for a time period corresponding to the animation time of zero timing entity travel. The statement is effective only is animation has been enabled on the Run menu of the Menu bar.

`ResetStatistics([ClearTimeSeries=True])`
Statement. Clears all recorded statistics data for the current simulation replication and reinitializes recording. The optional boolean argument *ClearTimeSeries* determines whether or not time series data is cleared for Graph servers and Spreadsheet Posts. If the value *False* is passed for the argument with the procedure

call, all previously recorded time series data are preserved, whereas these data are discarded by default.

`Animated`
Property(Boolean). Activates or deactivates the simulation animation. When the animation is activated or deactivated by the Animated property the check value of the **Animation** item on the Run Menu and Toolbar is updated. If the simulation is deactivated in Presentation mode, the Animation menu item is disabled in addition. When the button is disabled the animation can no longer be reactivated by user actions. The animation button is enabled again when the animation is reactivated by the Animated property or when the simulation is reset by the user. The Animated property is not functional if the animation has been deactivated by the user. This restriction was imposed to ensure that the maximum simulation speed is obtained if a simulation is run without animation.

`AnimationSpeed`
Property(Integer). Returns or sets the simulation animation speed. Accepted values for assignment of the property are integers in the range 0 to 101. The function returns *Void* if the property has not been set previously by this procedure. Assigning *Void* to the AnimationSpeed property resets the animation speed to the user-specified value. When the animation speed is set by the AnimationSpeed property, the Animation speed slider on the Toolbar is updated. If the simulation is in Presentation mode the slider is also disabled, such that the animation speed can no longer be changed by user actions. The slider is enabled again when the AnimationSpeed property is reset or when the simulation is reset by the user.

`IsVoid(X)`
Function(Boolean). Returns the boolean value *True* if the argument *X* is or evaluates to the Void object.

7.5 Entity procedures

Entity procedures are called on an entity object. They are used to obtain information on the status of the referenced entity or to cause the entity to undergo some transformation. Entity references are obtained from the `Item` procedure of the Residents, RuleResidents and Travels assemblies, the object procedures `SelectedResident`, `UniteEntity`, and from the global procedure `ScriptEntity`. The following Entity procedures are defined:

Object-referencing procedures

`Icon`
Property(Object). Returns or sets the Icon property of the entity as specified by the argument *Object.* The argument is passed as object reference to a picture component. For this property the default entity icon is referenced by *Void*.

`Host`
Function(Object). Returns the storage location of the entity. If the entity is stored in a link or server object, the function returns the object; if the entity is not stored it returns *Void*.

`Source`
Function(Object). Returns the link object by which the entity was created. The function returns *Void* if the Tracking property was not applied to the creating link when the entity was created.

Property-referencing procedures

`Identifier`
Property(String). Returns or assigns a unique identifier string to an entity. The procedure accepts any non-empty string value that does not contain the dot character as argument. The property assignment raises an error if the assigned string is used as identifier by another entity.

`ResidentsIndex`
Function(Integer). Returns the position of the entity in the Residents assembly of its host. The function returns the value zero if the entity is not stored in a server or link object.

`RuleResidentsIndex`
Function(Integer). Returns the position of the entity in the RuleResidents assembly of the host server of the entity. The function returns the value zero if the entity has no host server, or the entity is not a member of RuleResidents assembly of the host server. The function can only be called within a Select collect incident script of a server.

`TravelsIndex`
Function(Integer). Returns the position of the entity in the Travels assembly of the link on which it travels. The function returns the value zero if the entity is not traveling.

`Entry`
Function(Floating point). Returns the simulation time at which the entity was stored in its Host. The procedure causes a runtime error if the entity is not stored in a host object.

`Departure`
Property(Floating point). Returns or assigns the projected simulation time for dispatch or expiration of the entity. The *Void* value signifies that no dispatch or

expiration event exists to remove the entity from its host server. The procedure can be used to change the timing property of a resident entity and to determine the residual residence time in a Remove incident. The procedure causes a runtime error if the entity is not stored in a server object.

`Progress`
Function(Floating point). Returns the fractional progress of travel on a link. The procedure causes a runtime error if the entity is not traveling. The function returns *Void* for entities traveling with zero travel time, regardless of the animated travel progress.

`Speed`
Property(Floating point). Returns or assigns the travel speed of the entity. The travel speed is defined as the reciprocal value of the travel time, with the value *Void* denoting a zero travel time value. The speed of entities with zero travel time cannot be changed. The procedure causes a runtime error if the entity is not traveling on a link.

`Bonded`
Function(Boolean). Returns *True* if an entity is bonded, and *False* it is not.

`Retracted`
Function(Boolean). Returns *True* if the entity is in the retracted state, as a result of deferred retraction.

`IsUniteEntity`
Function(Boolean). Specifies if the entity is the UniteEntity of a server or a link object.

Miscellaneous procedures

`Extract(RecipientLink)`
Statement. Removes the entity from storage in a link or server object and moves it to the link object specified by the *RecipientLink* argument. Removal of an entity by this statement causes a Relocation incident. The *RecipientLink* argument can be any link object in the project. If the entity is not stored in an object, the statement call causes a runtime error. The Entity procedure `Host` can be used to determine if an entity is stored in an object.

7.6 Server procedures

Server procedures are called on a server object. They are used to obtain information on the status of the referenced server or to cause the server to undergo some transformation. Servers are usually references by the server name. The following server procedures are defined:

General property-referencing procedures

`Name`
Function(String). See: Shared procedures.

`Index`
Function(Integer). See: Shared procedures.

`RootName`
Function(String). See: Shared procedures.

`Caption`
Property(String). Returns or sets the Caption property of a server object. Not available for graph servers.

`Picture`
Property(Object). Returns or sets the Picture property of the server as picture component object. For this statement, the default picture property of the server is referenced by *Void*. Not available for graph servers.

`PictureReset`
Statement. Restores the initial, reset-status Picture property of a server. Not available for graph servers.

`Enabled`
Property(Boolean). The Enabled procedure inversely returns or sets the Disabled property value of a server. The procedure name differs from the server property name to prohibit conflict with the Disabled statistical function. Disabling a server in a simulation run causes an interruption and enabling an active server starts an new collection procedure. Not available for fusion and graph servers.

Operative property-referencing procedures

`Timing; Capacity; Priority; Shielding ([Applied=False])`
Property(Variant). These property procedures return or set the namesake property of the server object. Permitted value ranges for assignment of the properties are given for the individual properties in the corresponding Server properties topic. By default, the procedure returns the initially or last assigned value, which can be a reference to a component object. If the value *True* is passed for the optional argument *Applied*, the property returns the last applied value. The *Applied* option has no effect on property assignments.

`TimingReset; CapacityReset; PriorityReset; ShieldingReset`
Statement. Restores the initial, reset-status value of the corresponding property of the server.

`PassiveRule; CollectRule; DispatchRule`
Property(Variant). These property procedures return or set the corresponding rule property of a server object. The assigned value must be passed either as component object or as string, e.g. “FIFO”, “Cycle”, etc. Permitted value ranges for assignment of these properties are discussed in the corresponding Server properties topic. The

value *Void* can be assigned to remove a previously assigned component object and restore the constant value.

`PassiveRuleReset; CollectRuleReset; DispatchRuleReset`
Statement. Restores the initial, reset-status value of the rule corresponding property of a server object.

`Integrated; Certified; Bonding; Premature; Disordered; Discrete; Uniting; Revoking; Preemptive; Abortive; Interruptive`
Property(Boolean). These property procedures return or set the value for the namesake Boolean property of a server object. The boolean properties Active and Disabled are accessed by the below-mentioned `IsActive` and `Enabled` procedures. Changing the Uniting, Integrated, Premature or Disordered property of an active server causes an interruption.

`IsActive`
Property(Boolean). Specifies if the server is in the Active operation mode. Changing this property of a server causes an interruption. The scripting procedure name differs from the server property name to prohibit conflict with the default template of the Toolbox.

Link-referencing procedures

`LinkFrom(Origin,[Instance=1])`
Function(Object). Returns a collecting link object as specified by the arguments *Origin* and *Instance*. The *Origin* argument represents the origin server of the returned link object. The optional argument *Instance* has default value unity and represents the top-down sequence number of the link connections of the server with *Origin* as origin server. If a value for *Instance* <= 0 is passed the links are counted in reversed order, where the value 0 refers to the link with the highest connection number. The function returns *Void* if the server has no link connection with *Origin* and a runtime error is raised if *Instance* refers to a sequence number higher than the number of subjected link connections.

`LinkTo(Destination,[Instance=1])`
Function(Object). Returns a link object connected to the downstream side of the server as specified by the arguments *Destination* and *Instance*. The *Destination* argument represents the destination server of the returned link object. The optional argument *Instance* has default value unity and represents the top-down sequence number of the link connections of the server with *Destination* as origin server. If a value for *Instance* <= 0 is passed the links are counted in reversed order, where the value 0 refers to the link with the highest connection number. The function returns *Void* if the server has no link connection with *Destination* and a runtime error is raised if *Instance* refers to a sequence number higher than the number of subjected link connections.

`SelectedLink(Side)`
Function(Object). Returns the link selected by the Collect rule or Dispatch rule properties of the server, depending on the value passed for the argument *Side,* which has the same function as for the `Links` procedure. The function returns *Void* if no link has been selected in the selection routine addressed by the *Side* argument. The functions `SelectedCollectingLink` and `SelectedDispatchingLink` can be used as alternative to the `SelectedLink` function, omitting the *Side* argument.

Assembly-referencing procedures

`Links(Side)`

Function(Object). Returns an assembly of link objects connected to the server, as specified by the argument *Side.* The values -1 or "collecting" can be passed to address collecting links, and the values 1 or "dispatching" for dispatching links. The two string values for the *Side* argument are case-insensitive and may be abbreviated to any number of characters. The links are positioned in the assembly by top-down connection order. The functions `CollectingLinks` and `DispatchingLinks` can be used as alternative to the `Links` function, omitting the *Side* argument. The assembly shares the standard assembly procedures with other assemblies. The link procedure `LinksIndex` can be used to determine the position of a specific link in the assembly.

`RuleLinks`

Function(Object). Returns an assembly of link objects subjected to the selection routine by the Collect rule or Dispatch rule properties of the server. The links are positioned in the assembly by top-down connection order The procedure can be called only within a Select collect incident or Select dispatch incident, and only on the script object. The scripting incident determines which selection routine the RuleLinks assembly represents. The assembly shares the standard assembly procedures and the rule assembly procedures with other assemblies. The link procedure `RuleLinksIndex` can be used to determine the position of a specific link in the assembly.

`Residents`

Function(Entity). Returns an assembly of resident entities of the server See: Shared procedures.

`RuleResidents`

Function(Object). Returns the assembly of entities subjected to the selection routine by the Passive rule of the server. The entities are positioned in the assembly by order of arrival. The procedure can be called only within a Select collect incident script of a passive server, and only on the script object. The assembly shares the standard assembly procedures and the rule assembly procedures with other assemblies. The entity procedure `RuleResidentIndex` can be used to determine the position of a specific entity in the assembly.

Resident-referencing procedures

`UniteEntity`

Function(Entity). Returns the target entity of a Unite incident. See: Shared procedures.

`SwapResidents(Pos1, Pos2)`

Statement. Switches the positions of two entities stored in the server. The `SwapResidents` procedure call resets any prior configurations made to the RuleResidents assembly by the `Exclude` statement. See: Shared procedures.

`SelectedResident`

Function(Object). Returns the entity selected for retrieval from a passive server. The property returns *Void* if no entity has been selected.

Resource-related procedures

`Capacity; Priority ([Applied=False])`

Property(Variant). These property procedures return or set the namesake property of the server object. These procedures are used in the same way as the corresponding Operative properties-referencing procedures.

`Allocation(Index,[Applied=False])`
Property(Variant). Assigns or returns the Allocation requirement of a resource server for an active server. The procedure can be called on resource servers and on active servers. If the procedure is called on an active server, the *Index* argument specifies the resource server object of the allocation requirement addressed by the procedure. If the procedure is called on a resource server, the Index argument can be either an integer or an active server object. If the argument is an active server, it specifies the server of the allocation requirement addressed by the procedure. If it is an integer, the argument specifies the position of the allocation requirement in the allocation preference order of the resource server. If the value *True* is passed for the optional argument *Applied*, the property returns the last applied value. The *Applied* option has no effect on property assignments.

`AllocationReset(Index)`
Statement(). Restores the initial, reset-status value of the Allocation requirement specified by the Index property. The Index property has the same function as for the above-mentioned Allocation procedure.

`AllocationLoad(Index)`
Function(Integer). Returns the current number of resources allocated by a resource server to an active server. The Index property has the same function as for the above-mentioned Allocation procedure.

`AllocationRule`
Property(Variant). Returns or assigns the Allocation Rule property of a server object. The assigned value must be passed either as component object or as string, e.g. “Cycle”, “Random”, “Order”. The value *Void* can be assigned to remove a previously assigned component object and restore the constant value.

`AllocationRuleReset`
Statement. Restores the initial, reset-status value of the above-mentioned Allocation Rule property of a resource server.

Graph-related procedures

`ContentText([LineIndex])`
Property (String). Returns or sets a line of the Content text property of a graph server object. The optional argument *LineIndex* specifies the line number, starting at 1 for the first line. If a value for *LineIndex* <= 0 is passed, the lines are counted in reversed order, where the value 0 refers to the last line. If the argument is omitted, all lines are set or returned with the VBscript string constant *VbCrLf* as line separator. The property call causes a runtime error if the *LineIndex* argument addresses a line number greater than the number of lines in the Content text property.

`AttributeEntity( [SeriesItem, [Instance=1]] )`
Property (Entity). Assigns an entity to the Data series item specified by the optional arguments *SeriesItem and Instance*. There are three ways to pass the *SeriesItem* argument: If the argument is an Attribute component, it represents the Series object. If the argument is a string, it represents the series name, and if it is an integer number, it represents the series order number. The *Instance* argument is an integer with default value 1, which represents the sequence number of the *SeriesItem* argument occurrence in the data series list (The Series name and Series object are not unique). If both arguments are omitted, the first Data series of the Graph is addressed. The entity assignment is removed by assigning *Void* is to the property, which causes the series data to be cleared. The property assignment causes a runtime error if the addressed data series does not have an Attribute assigned as

Series object, or if the addressed Attribute component is not a Series object of the server.

The AttributeEntity property has no return value. As a consequence, the entity assigned to a series item cannot be retrieved by scripting. The below-mentioned `HasAttributeEntity` function may be used to determine whether or not an entity has been assigned to an Attribute series. The procedure also is also defined without arguments for Spreadsheet posts.

`HasAttributeEntity( [SeriesItem, [Instance=1]] )`
Function (Boolean). Returns true if an entity has been assigned by the above-mentioned AttributeEntity property procedure to the Data series specified by the arguments *SeriesItem and Instance*. The two arguments are used in the same manner as in the above-mentioned AttributeEntity property procedure. The procedure is also defined without arguments for Spreadsheet posts.

Statistical functions

`Residence; Population; Utilization; Dimension; Occupied; Idle; Disabled ([StatParam="current"], [UseVoid=False])`
Function(Variant). Statistical functions returning recorded statistical data of the server. The function names correspond to the recorded server properties, and the optional argument *StatParam* specifies the statistical parameter. The following string values can be passed for the case-insensitive argument *StatParam*:

- "current" (Default)
- “pending”
- "observations"
- "sum"
- "mean"
- "variance"
- "minimum" ."mn", "n"
- "maximum", "mx", "x"
- "arrivals" (Residence function)
- "time-averaged" (Population, Utilization and Dimension functions)
- "fraction" (Occupied, Idle and Disabled function)

The functions also recognize the *StatParam* argument string if truncated to any number of characters, except for the "minimum" and "maximum" arguments, which require at least two characters or one of the alternatives indicated in the list. By default, the functions returns the integer value 0 if the server object has no data for an argument value passed for *StatParam* other than *"current",* unless *True* is passed for the optional argument *UseVoid,* in which case the functions return *Void* instead. The `Residence`, `Population`, `Occupied` and `Idle` functions are also available for Fusion servers. The `Residence` function with argument *"Arrivals"* is also available as server function `Arrivals()`.

`IsOccupied; IsIdle; IsDisabled`
Function(Boolean). Statistical functions returning *True* if the current server status matches the namesake function.

Miscellaneous procedures

`PositionShift(dx,dy)`
Statement. Changes the position of a server on the Worksheet. The arguments *dx* and *dy* are floating point numbers specifying the translation distances in horizontal and vertical directions. The translation in horizontal direction is given by the product

of argument *dx* and the server picture width and in vertical direction by the product of *dy* and then picture height.

`PositionReset`
Statement. Moves the server to its initial, reset-status position on the Worksheet.

`Interrupt([Level=0])`
Statement. Invokes a server interruption. The optional *Level* argument is an integer number which determines the potency of the call. The Interrupt statement is canceled if the *Level* argument is smaller than the Shielding value of the server.

`InterruptAllowed`
Function(Boolean). Returns *True* if server interruption can be performed instantly. If the function returns *False*, the operative collection procedure of the server does not allow immediate interruption of the server, and the interruption will be postponed and performed by a calendar event.

`Interrupted`
Function(Boolean). Returns true if a server has the interrupted status.

`Retract([Level=0])`
Function(Integer). For resource servers the procedure forces deallocation of all resources allocated by the server. For active servers, the procedure calls the `Retract` statement on all collecting links of the server (See: Shared procedures).

`UniteNumerator`
Function(Integer). See: Shared procedures.

`UniteDenominator`
Function(Integer). See: Shared procedures.

7.7 Link procedures

Link procedures are called on a link object. They are used to obtain information on the status of the link object or to cause the link to undergo some transformation. Links are usually referenced by link-referencing server procedures. The following link procedures are defined:

Property-referencing procedures

`Name`
Function(String). Returns an descriptive identifier for the link. See: Shared procedures.

`Batch; CollectWeight; Required; Excess; Departures; DispatchWeight; Travel ([Applied=False])`
Property(Variant). These property procedures return or set the namesake property of a link object. Permitted value ranges for assignment of the properties are given in the Link properties topic. By default, the procedure returns the initially or last assigned value, which can be a reference to a component object. If the value *True* is passed for the optional argument *Applied*, the property returns the last applied value. The *Applied* option has no effect on property assignments.

`BatchReset; CollectWeightReset; RequiredReset; ExcessReset; DeparturesReset; DispatchWeightReset; TravelReset`
Statement. Restores the initial, user-specified value of the corresponding property of the link.

`Mandatory; Solitary; Suspending; Claiming; Escort; Independent; Overflow; Expiration; Discard; Initializing; Completing; Tracking; Upstream; Uniting`
Property(Boolean). These property procedures return or set the corresponding property value of the link. Changing the Completing, Mandatory, Solitary, Required, Suspending; Claiming, Uniting or Upstream property of a link may cause an interruption of the destination server.

Connectivity-related procedures

`Origin`
Function(Server). Returns the origin server object of the link. For creating links the function returns *Void*.

`Destination`
Function(Server). Returns the destination server object of the link. For deleting links the function returns *Void.*

`LinksIndex(Side)`
Function(Integer). Returns the link position in the Links assembly corresponding with the argument *Side*. The side argument specifies the server connection side and has the same function as for the server assembly procedure `Links`. The functions `DestinationIndex` or `CollectingLinksIndex` can be used as alternative to the `LinksIndex` function with argument *Side* = -1. The functions `OriginIndex` or `DispatchingLinksIndex` can be used as alternative to `LinksIndex(1)`.

`RuleLinksIndex`
Function(Integer). Returns the position number for the link in the RuleLinks assembly of the script object. The function can be called only within a Select collect incident or

Select dispatch incident. The function causes a runtime error if the link is not connected to the script object. The function returns the value zero if the link is not a member of the RuleLinks assembly.

`RuleSelectable`
Function(Integer). Returns true if the link is selectable by the selection routine of the Collect rule or the Dispatch rule. The function can be called only within a Select collect incident or Select dispatch incident. The function causes a runtime error if the link is not connected to the script object.

Assembly-referencing procedures

`Residents`
Function(Entity). Returns an assembly of the resident entities of the link See: Shared procedures.

`Travels`
Function(Entity). Returns an assembly of the entities traveling on the link. The entities are positioned in the assembly by order of travel start. The assembly shares a number of standard assembly procedures with other assembly types. The entity procedure `TravelsIndex` can be used to determine the position of a specific entity in the assembly.

Resident-referencing procedures

`UniteEntity`
Function(Entity). Returns the target entity of a Unite incident. See: Shared procedures.

`SwapResidents(Pos1, Pos2)`
Statement. Switches the positions of two entities stored in the link buffer. See: Shared procedures.

Statistical functions

`Residence; Population ([StatParam="current"], [UseVoid=False])`
Statistical functions returning recorded statistical data of the link. The function names correspond to the recorded server properties. The optional arguments *StatParam* and *UseVoid* have the same function as for the corresponding statistical functions of servers.

Miscellaneous procedures

`EntityCreate([N=1])`
Statement. Creates entities on a creating link. The number of entities created is specified by the optional argument *N*, which is an integer number >= 0. An error is raised if the statement is called on a non-creating link

`Retract([Level=0])`
Statement. Invokes the Retraction procedure on a creating-type link. See: Shared procedures.

`UniteNumerator`
Function(Integer). See: Shared procedures.

`UniteDenominator`
Function(Integer). See: Shared procedures.

7.8 Component procedures

Component procedures are called on a component object or a Data association. They are used to obtain information on the status of the object or to cause the component to undergo some transformation. Components are usually referenced by their Name property. The following component procedures are defined:

Variable procedures

`Name`
Function(String). See: Shared procedures.

`Index`
Function(Integer). See: Shared procedures.

`RootName`
Function(String). See: Shared procedures.

`Eval`
Function(Variant). References the current value of a variable component. See: Shared procedures.

`Value([StatParam="current"], [UseVoid=False])`
Function(Variant). Returns recorded data of a variable component. See: Shared procedures.

Attribute procedures

`Name`
Function(String). See: Shared procedures.

`Index`
Function(Integer). See: Shared procedures.

`RootName`
Function(String). See: Shared procedures.

`Eval`
Function(Variant). References the current value of an entity attribute component. See Shared procedures.

`Recording([EntID=””])`
Property(Boolean). Assigns or returns the statistics recording status of the entity attribute. If the property is assigned to an entity that doesn’t have an Identifier, the entity is given a generic identifier value, composed of the letter *E* combined with a serial number. The optional string argument *EntID* replaces the generic identifier. The *EntID* argument is ignored if its value is in use as identifier of another entity and if the procedure is called to retrieve the Recording property. The attribute recording status can be viewed for all entity attributes on the Data tab of the Object properties console.

`RecordingOption(OptionName)`
Property(Boolean). Assigns or returns a statistics recording option of the entity attribute. The recording option addressed is determined by the string argument *OptionName*. The argument can have one of the following values: “*ReportIncluded”, “IgnoreDefault”, “IncludePending”* and *“ExcludeInstant”,* which correspond respectively with the properties Report included, Ignore default, Include value and, Exclude value on the Object properties console. The procedure call raises an error if statistics recording has not been enabled for the entity attribute by the above-mentioned Recording procedure.

`Value([StatParam="current"], [UseVoid=False])`
Function(Variant). Returns recorded data of the entity attribute. See: Shared procedures.

Distribution procedures

`Name`
Function(String). See: Shared procedures.

`Index`
Function(Integer). See: Shared procedures.

`RootName`
Function(String). See: Shared procedures.

`Eval`
Function(Variant). Returns the evaluation result of a distribution component. See Shared procedures.

`Parameters(Index,[Rndvar=False])`
Property(Number). Returns or assigns the distribution component parameter specified by the argument *Index*. The *Index* argument is an integer number that represents the sequence number of the parameter, in the order given in the column labeled *Parameters* of the pdf-list, starting with the value 1. The permitted value ranges for parameter assignment are also indicated in the list for all available distribution functions. The optional argument *Rndvar* can only be used for the Piecewise distribution function. If the value *True* is passed for the argument *Rndvar* the property call targets the random variable property of the distribution component, whereas the probability density parameter is targeted by default.

`ParametersSet(Param1,[Param2,[…]])`
Statement. Sets all parameters of a distribution component to the values passed as arguments *Param1…ParamN*. A runtime error is raised if the number of parameters passed with this statement does not match the parameter number of the distribution component. For the Piecewise distribution function the parameters are passed as a series of coordinate pairs for the curve points.

`ParametersReset`
Statement. Restores the initial, reset-status values of the distribution component parameters.

Schedule procedures

`Name`
Function(String). See: Shared procedures.

`Index`
Function(Integer). See: Shared procedures.

`RootName`
Function(String). See: Shared procedures.

`Run`
Function(Integer). Activates the schedule component. All schedule components can be activated by this procedure if they are Dormant or have been deactivated by the below-mentioned Terminate procedure. For a schedule component that uses the *Simulation time* Method, multiple instances can be started. The function returns the identifier of the instance being started. The identifier is an integer number with value zero for the first schedule instance and a unique number > 0 for additional instances.

The identifier is to be passed as argument to the below-mentioned Terminate statement to deactivate the schedule instance. Therefore, the identifier must be stored somewhere, for example in a variable component, in order to be able to deactivate a supplemental schedule instance at some point in the simulation. The function returns the value 0 for the *Clock time* and *Simulation state* Methods, and causes a runtime error if the schedule has already been activated. If the schedule is recurrent, the Run procedure activates the schedule on the first following complete day in the simulation clock.

`Terminate([RunID=0])`
Statement. Deactivates an instance of the schedule component. The optional argument *RunID,* with default value zero, is the identifier of the schedule instance being terminated. The instance identifier has the value zero for automatically activated schedule instances. For instances activated by the above-mentioned schedule procedure Run, its value is given by the return value of the Run procedure call.

`RowIndex`
Function(Integer). Returns the row number for the schedule item being executed. The value returned corresponds to the row number indicated in the schedule grid_Schedule_grid. The function is available only if the schedule component is referenced by `ScriptObject`.

`ColumnIndex`
Function(Integer). Returns the column number of the schedule item being executed. The value returned corresponds to the column number listed in the top row of the schedule grid. The function is available only if the schedule component is referenced by `ScriptObject`.

Picture procedures

`Name`
Function(String). See: Shared procedures.

`Index`
Function(Integer). See: Shared procedures.

`RootName`
Function(String). See: Shared procedures.

Data association procedures

`Name`
Function(String). See: Shared procedures.

`Index`
Function(Integer). See: Shared procedures.

`RootName`
Function(String). See: Shared procedures.

`AttributeEntity`
Property (Entity). Assigns an entity to the data association. The property assignment causes a runtime error if the data association does not have an attribute specified as association object. The entity assignment is removed if the property is set to *Void*. The AttributeEntity property has no return value, which has as a consequence that the assigned entity cannot be retrieved. The `HasAttributeEntity` function may be used to determine whether or not an entity has been assigned to a spreadsheet

attribute data association. The procedure is also defined with arguments for graph servers.

`HasAttributeEntity`
Function (Boolean). Returns true if an entity has been assigned to an attribute data series by the above-mentioned AttributeEntity property. The procedure is also defined with arguments for graph servers.

7.9 Clock procedures

The Renque Simulation clock is referenced by the global procedure `Clock`. The simulation clock has a number of properties that are accessible by scripting procedures. They are mostly used to obtain information on the progress of a simulation run. Clock procedures include procedures to determine the simulation time and time span, including functions to obtain timing information within the reference frame of the 12 or 24-hour clock system and built-in calendar.

General clock procedures

`SimTime`
Function(Real). Returns the simulation time as a floating-point number. Also available as global procedure.

`ClockTime([Formatted=False], [TimeOnly=False])`
Function(Various). Returns the current clock time. By default, the ClockTime function returns the clock parameter as floating point number. If the value *True* is passed for the optional argument *Formatted* and a Time unit has been specified, the return value of the ClockTime function is formatted in the date/time representation of the operating system. If also the value *True* is passed for the optional argument *TimeOnly,* the date part of the clock parameter is left out the return value. Without arguments, the function can also be called as global procedure..

`CalendarDate`
Function(Variant). Returns calendar date of the clock time in the date format of the operating system. A runtime error is raised if the Use Calendar is not applied to the clock properties.

`SimStart`
Function(various). Returns the simulation start value for the clock time. The data type returned depends on the clock properties applied. By default, the function returns a floating-point number. If a Time unit is specified for the simulation time the `SimStart` function returns an integer number in the range 1 (Sunday) to 7 (Saturday) representing the start weekday of the simulation. If the Use Calendar property is applied the function returns the calendar start day in the system's date format.

`SimRunTime`
Function(Floating point). Returns the Maximum run time for simulation replications. If the RunTime option of the simulation time span properties is not applied the function returns *Void*.

`SimStartupTime`
Function(Floating point). Returns the Shared startup time. If the Startup time option of the simulation time span properties is not applied the function returns *Void*.

`SimTermination`
Function(Date). Returns the simulation Termination date in the system's date format. If the Termination option of the simulation time span properties is not applied the function returns *Void*.

`ReplicationNumerator`
Function(Integer). Returns the current replication number

`ReplicationDenominator`
Function(Integer). Returns the total number of replication runs to be performed for the current simulation.

`ReplicationTerminate`
Statement. Forces termination of the current replication and starts the next replication, or ends the simulation run if all replications have been completed.

Clock time functions

Calendar functions return information of the simulation progress in relation to of the 12-or 24-hour clock system. If no Time unit has been specified for the simulation time an error is raised when a Clock time function is called. The available Clock time functions are:

`FirstWeekDay`
Function(Integer). Returns the day number of the first weekday of the clock time as an integer number between 1 (Sunday) and 7 (Saturday).

`TimeWeekday`
Function(Integer). Returns the day number of the current clock time day as a whole number between 1 and 7. The number 1 corresponds to the First weekday assigned to the simulation clock.

`TimeHour`
Function(Integer). Returns the hour of the current day of the clock time.

`TimeMinute`
Function(Integer). Returns the minute of the current hour.

`TimeSecond`
Function(Integer). Returns the second of the current minute.

`Weeks([T=ClockTime], [WeekDayBased=False])`
Function(Integer). Returns the number of completed weeks in the simulation clock at clock time T. If no value is passed to the function for the argument *T* the function returns the result for the current clock time. By default, the function returns the number of completed 7-day periods. Passing the value *True* to the *WeekDayBased* argument forces the function to count the number of First weekday occurrences in the simulation clock, excluding the simulation start day.

`Days([T=ClockTime])`
Function(Integer). Returns the number of whole days in the simulation clock at clock time T. If no value is passed to the function for the argument *T* the function returns the result for the current clock time.

`Hours([T=ClockTime])`
Function(Integer). Returns the number of whole hours in the simulation clock at clock time T. If no value is passed to the function for the argument *T* the function returns the result for the current clock time.

`Minutes([T=ClockTime])`
Function(Integer). Returns the number of whole minutes in the simulation clock at clock time T. If no value is passed to the function for the argument *T* the function returns the result for the current clock time.

`Seconds([T=ClockTime])`
Function(Integer). Returns the number of whole seconds in the simulation clock at clock time T. If no value is passed to the function for the argument *T* the function returns the result for the current clock time.

Calendar functions

Calendar functions return information of the simulation progress in relation to the simulation clock calendar. If the Use Calendar property is not applied to the simulation clock an error is raised when one of the calendar functions is called. The available calendar functions are:

`DateYear`
Function(Integer). Returns the year number of the clock time.

`DateQuarter`
Function(Integer). Returns the quarter number of the current year of the clock time.

`DateMonth`
Function(Integer). Returns the month number of the current year of the clock time.

`DateWeek`
Function(Integer). Returns the week number of the current year of the clock time.

`DateDay`
Function(Integer). Returns the day number of the current month of the clock time.

`Years([T=ClockTime])`
Function(Integer). Returns the number of calendar year changes in the simulation at clock time T. If no value is passed to the function for the argument *T* the function returns the result for the current clock time

`Months([T=ClockTime])`
Function(Integer). Returns the number of calendar month changes in the simulation at clock time T. If no value is passed to the function for the argument *T* the function returns the result for the current clock time.

7.10 Shared procedures

Standard assembly procedures.

Renque assemblies are objects representing a group of related links or entities. Assemblies are defined for server and link objects. The assembly objects share a number of general assembly procedures, which can be used to reference assembly members, return information about the assembly composition, and to perform transformations on the assembly members.

`Item(Index)`

Function(Object). Returns a member of an assembly. The argument *Index* specifies the position of the member in the assembly. If a value <= 0 is passed for the *Index* argument, the counting order is reversed, with the value 0 representing the last item. A runtime error is raised if the *Index* argument refers to a position larger than the number of items in the assembly. As default assembly procedure, the Item procedure can be omitted in scripting by passing the *Index* argument directly to the assembly. For example: the scripts `.Residents.Item(1)` and `.Residents(1)` are equivalent.

`Count([Criterion=""])`

Function(Integer). Returns the number of assembly members. The optional argument *Criterion* can be applied to restrict the count operation to items that meet certain requirement. The *Criterion* argument must be a script snippet that evaluates to a Boolean value. The assembly members addressed by the *Criterion* argument are referenced by the global procedure `Member`. For example, the script

```
.CollectingLinks.Count(Member.Batch = 1)
```

counts the number of links in the assembly with a Batch value of 1. And the script:

```
.Residents.Count(IsVoid(Member.Icon))
```

counts the number of resident entities with the default entity icon. If the *Criterion* argument does not return a boolean value for one or more assembly members, the function creates an entry in the Runtime error viewer, but does not cause an actual runtime error. The function returns *Void* if the *Criterion* argument returns a non-boolean value for all members.

`Assess(Property, Param)`

Function(number). Returns an assembly property, derived from its members, as determined by the arguments *Param* and *Property*. The argument *Param* specifies the derivation type. Applicable values for the *Param* argument are *"Sum", "Mean", "Variance", "Minimum" and "Maximum"*. The derivation objective is specified by the *Property* argument, which is passed as a script snippet which represents a member property that returns a numeric value. For example, the script:

```
.RuleLinks.Assess(Origin.Population, "Sum")
```

returns the sum of the current Population of the origin servers of the link items in the assembly. And the script:

```
.Residents.Assess(Departure, "Maximum")
```

returns the maximum departure time of all residents in the assembly. The Property argument can be an attribute component for entity assemblies or a variable component for link assemblies in order to assess entity attribute values or local variable values. If the *Property* argument does not return a numerical value for one or more assembly members, the function creates an entry in the Runtime error viewer, but does not cause an actual runtime error. The function returns *Void* if the assembly is empty or the *Property* argument returns a non-numerical value for all members.

`Sweep(Operation)`
Statement. Executes the script specified by the argument *Operation* consecutively on all members of the assembly. The assembly members addressed by the *Operation* argument are referenced by the global procedure `Member`. For example:
`.RuleLinks.Sweep(if Member.Batch=3 then Member.Batch=2)`
changes a Batch value of 3 into 2 for all member links in the referenced RuleLinks assembly.

`HasItem(Criterion="")`
Function(Boolean). Verifies if the assembly has at least one member that meets the requirement specified by the argument *Criterion*. The mandatory *Criterion* argument has the same syntax structure and function as for the assembly procedure `Count`. The function can be used as alternative to the procedure call
`.Count(Criterion)<>0`. It is considerably faster in case the assembly typically has a large number of members which regularly, but not necessarily, meet the *Criterion* requirement.

Assembly procedures for rule assemblies.

The server procedures `RuleLinks` and `RuleResidents` return assembly objects representing a group of links or entities subjected to a selection routine directed by the Passive rule, Collect rule or Dispatch rule properties of a server. The rule assemblies share a number of procedures, in addition to the standard assembly procedures, that allow control of the selection routine by incident scripting.

`Exclude(Criterion)`
Statement. Excludes items from the assembly that meet the requirement specified by the *Criterion* argument. The *Criterion* argument has the same syntax structure and function as for the assembly procedure `Count`. For example, the script command:
`RuleLinks.Exclude(Member.Origin.Population < 3)`
removes all links from the RuleLinks assembly with an origin server that has less than 3 residents. If the *Criterion* argument does not return a boolean value for one or more assembly members, the function creates an entry in the error viewer list, but does not cause an actual runtime error. The same happens if an Exclude statement call would result into exclusion of all members of the assembly, in which case the exclusion is not applied. Multiple calls of the Exclude statement in the same scripting incident result into additional exclusions.

`SelectMember(Member)`
Statement. Condenses the assembly to a single member by removing all members other than the item specified by the argument *Member.* The *Member* argument is either an object that represents a member of the assembly, or an integer number specifying the position of the object in the assembly in the same way as the *Index* argument of the `Item` assembly procedure. A runtime error is raised if the *Member* argument represents an object than is not a member of the assembly. Passing *Void* for the *Member* argument rebuilds the assembly and eliminates any prior exclusions resulting from the above-mentioned Exclude statement.

`CycleReset`
Statement. Clears the reference to the previously selected link under application of the *Cycle* value to the Collect rule or Dispatch rule server properties. Execution of this statement causes the next link selection procedure governed by the affected *Cycle* rule to pick the first link item in the RuleLinks assembly.

Procedures for server objects and all component types.

`Name`
Function(String). Returns the Name property of an object. For link objects a description is returned, which cannot be used to reference the link by scripting.

`Index`
Function(Integer). Returns the index number of an object. The index is given by the number which follows the space divider in the Name property. The function returns the value 0 if the Name property doesn't end with a number.

`RootName`
Function(String). Returns the Name property without the Index part and space divider.

Procedures for server and link objects.

`Residents`
Function(Entity). Returns an assembly of resident entities of a server or link buffer. The entities are positioned in the assembly by order of arrival. The assembly shares a number of standard assembly procedures with other assembly types. The entity procedure `ResidentsIndex` can be used to determine the position of a specific entity in the assembly.

`UniteEntity`
Function(Entity). Returns the target entity of Unite incidents. The function returns *Void* if no unite target entity has been stored in the host object.

`SwapResidents(Pos1, Pos2)`
Statement. Switches the positions of two entities stored in a link buffer or a server, as specified by the arguments *Pos1* and *Pos2*. The arguments are integer numbers representing the storage position of the resident in the object in order of arrival. If a value <= 0 is passed for the arguments, the position is counted in reversed order, with the value 0 representing the last entity stored. A runtime error is raised if the position number passed for the *Pos1* or *Pos2* argument refers to a resident position larger than the number of residents stored.

`Retract([Level = 0])`
Statement. Invokes the retraction procedure for a creating link when called as link statement. When called as server statement the Retraction procedure is invoked on all creating links of the server. The optional argument *Level* determines the potency of the Retract call.

`UniteNumerator`
Function(Integer). Returns the sequence number of the next Unite incident of a server or a link object. The function returns the value 0 if there is no unite entity stored in the object.

`UniteDenominator`
Function(Integer). Returns the number of Unite incident occurrences of a server or a link in the operative collection procedure, equal to the number of entities collected on the object less one. If the Uniting property is not applied or a server has no operative collection procedure the function returns the value 0.

Procedures for distribution, variable and attribute components.

`Eval`
Function(Variant). Returns the evaluation result of a variable, attribute or distribution component. Used to explicitly reference a value, as opposed to the component object

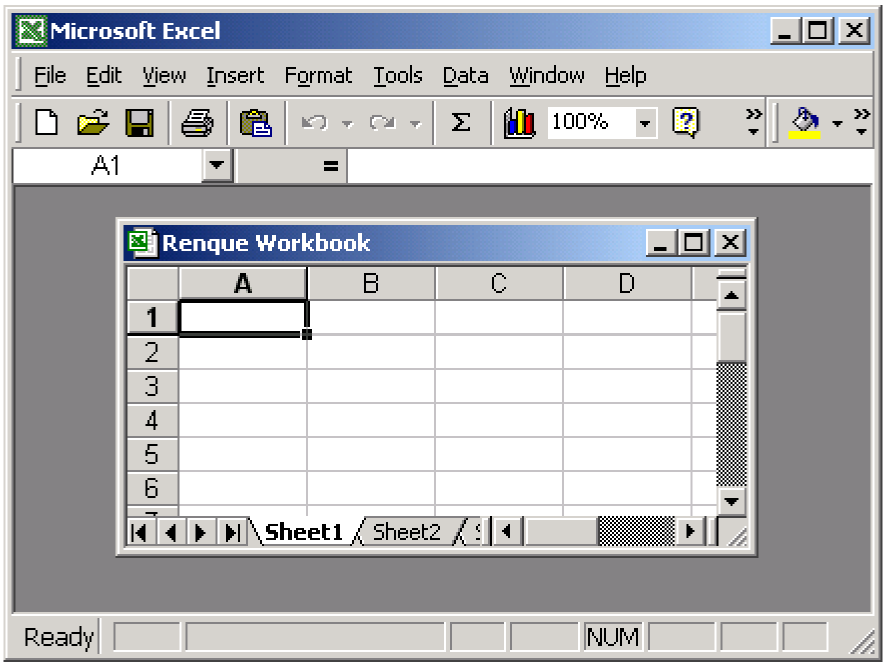
itself. The function causes a runtime error when called on a distribution component with an invalid parameter set.

Procedures for variable and attribute components.

`Value([StatParam="current"], [UseVoid=False])`
Function(Variant). Returns recorded statistical data of the component. The optional arguments *StatParam* and *UseVoid* have the same function as in the statistical server procedure `Population`. The function call with default argument “current” is equivalent to the `Eval` procedure.

8 Working with spreadsheets

Renque offers embedding of a *Microsoft Excel™* workbook into a simulation project. The **Spreadsheet application** command of the Tools menu starts an instance of Microsoft Excel and opens an embedded workbook, named *Renque Workbook*.



The embedded workbook is automatically saved in the project file and can be used to improve the organization, presentation and exchange of project properties and simulation results. Various object properties be associated with spreadsheet cells in the workbook, and simulation results can be transferred to a spreadsheet in different ways. Furthermore, the embedded workbook enables automated creation of objects and components from a list of specifications in the spreadsheet.

Spreadsheet embedding is not available on systems that do not have *Microsoft Excel* installed. However, an embedded workbook and all cell references contained in a Renque project file opened on such systems are preserved when the file is saved back.

Renque can pair with the embedded workbook in several ways. These are discussed in the following topics:

- Property associations
- Data report
- Data associations
- Spreadsheet interaction
- Spreadsheet scripting
- Spreadsheet import

8.1 Property associations

Most numeric properties of objects and components can be associated with the content of cells in the embedded workbook. A property association connects the content of a specific spreadsheet cell to an object property. When the cell value changes the associated property changes with it. The following object properties may be associated with spreadsheet cells:

- Server properties
  - Timing
  - Capacity
  - Priority
  - Shielding
  - Allocation requirement

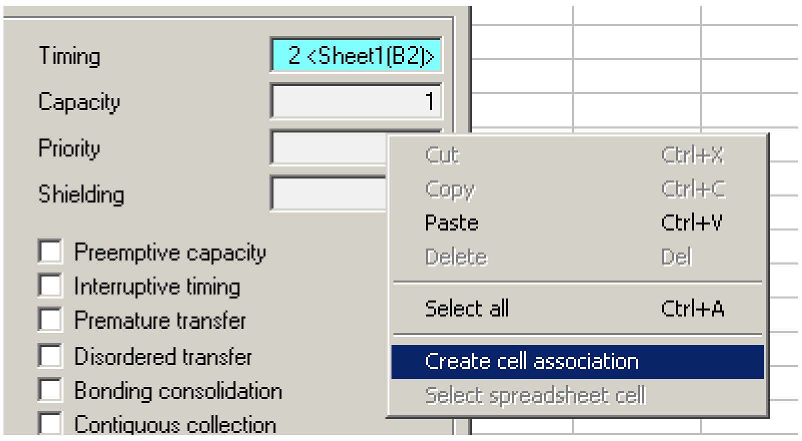
- Link properties
  - Travel time
  - Collect Weight
  - Dispatch Weight
  - Batch size
  - Excess permitted
  - Required availability
  - Departures number

- Variable properties and attribute properties
  - Default value

- Schedule properties
  - Timing

- Distribution properties
  - Parameter

property associations are assigned to an object property by the **Create cell association** item of the pop-up menu that appears upon a right mouse click on the property's control item on the Object properties console, as shown in the figure below.



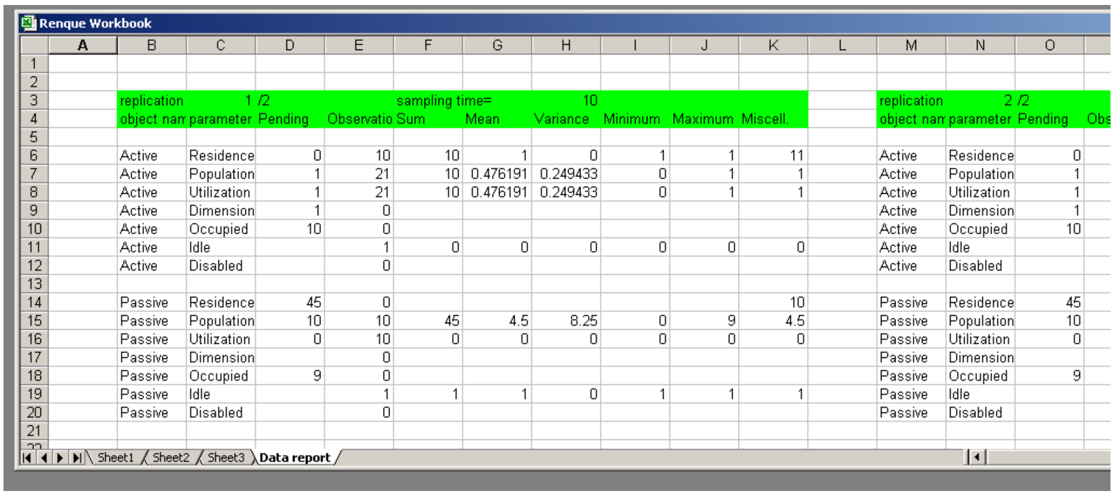
An existing cell association is indicated by a text string in the format: "*value <Sheetname(CellName)>*". In the figure, cell *B2* of worksheet *Sheet1,* containing the value *2,* was assigned to the timing property of a server. The cell association is accentuated with an alternative back color of the text field. If the cell contains a value that is not valid for the associating property the text color of the text field changes to red. Cell associations are simply removed by overtyping.

A sequence of property associations can be assigned to the default value of array variables and attributes, which allows for individual specification of cell associations for the default values for the array elements. These serial cell associations are assigned in the same manner as single cell associations, with the restriction that the assigned spreadsheet cell range must be continuous and have the same dimensions as the array. The descriptor format for such serial associations is <*Sheetname (Cellname1-CellName2)*>, where *Cellname1* and *CellName2* refer to the cell associations of the lower and upper array elements respectively. The individual associations may be viewed by the **Display list** item of the pop-up menu of the <u>Default value</u> field of the Variable properties frame and the <u>Default Value</u> field of the Attribute properties frame.

8.2 Data report

Renque has a data reporting feature which exports simulation results to an Embedded spreadsheet. The data reporting feature is disabled by default. It is enabled by the **Write data report** item of the Spreadsheets preferences. Recorded data are exported for all objects to which the Report included property is applied.

The report contains the statistical parameter values for all recorded object properties. Data are written to a set of 10 columns for each replication, as shown in the figure.



Renque Workbook

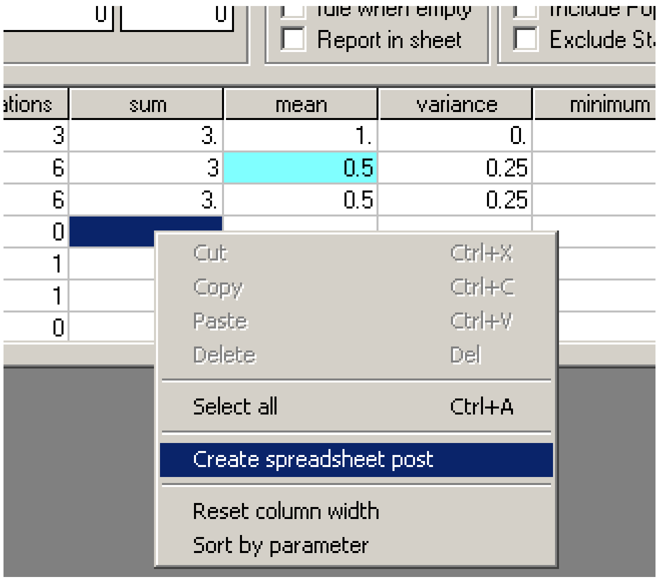
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	
1																
2																
3		replication	1	/2		sampling time=		10					replication	2	/2	
4		object narr	parameter	Pending	Observatio	Sum	Mean	Variance	Minimum	Maximum	Miscell.		object narr	parameter	Pending	Obs
5																
6		Active	Residence	0	10	10	1	0	1	1	11		Active	Residence	0	
7		Active	Population	1	21	10	0.476191	0.249433	0	1	1		Active	Population	1	
8		Active	Utilization	1	21	10	0.476191	0.249433	0	1	1		Active	Utilization	1	
9		Active	Dimension	1	0								Active	Dimension	1	
10		Active	Occupied	10	0								Active	Occupied	10	
11		Active	Idle		1	0	0	0	0	0	0		Active	Idle		
12		Active	Disabled		0								Active	Disabled		
13																
14		Passive	Residence	45	0						10		Passive	Residence	45	
15		Passive	Population	10	10	45	4.5	8.25	0	9	4.5		Passive	Population	10	
16		Passive	Utilization	0	10	0	0	0	0	0	0		Passive	Utilization	0	
17		Passive	Dimension		0								Passive	Dimension		
18		Passive	Occupied	9	0								Passive	Occupied	9	
19		Passive	Idle		1	1	1	0	1	1	1		Passive	Idle		
20		Passive	Disabled		0								Passive	Disabled		
21																

The data report is created when a simulation pauses or stops. All previous content of the sheet is overwritten when the data report is compiled.

8.3 Data associations

Data associations are used to post simulation data in spreadsheet cells of the Embedded spreadsheet. Data associations can be created for recorded data and current values of server and link objects and of variable and attribute components. By default, these associations write simulation results to a spreadsheet after a simulation run, but it is also possible to update the spreadsheet during a simulation run for specific data associations at user-definable intervals. Data associations can write the present values of an associated data field to a specific spreadsheet cell or write series of observations in columns, with the corresponding observation times in another, coupled column. The latter option allows for the display of simulation results as a function of time in Excel charts.

Data associations are created by the **Create spreadsheet post** item of the pop-up menus of the data sheets on the Data tab of the Object properties console, as shown in the figure below. Data associations are managed by the Data associations manager utility. An assigned data association is indicated on the data sheet by an alternative cell back color, as shown in the figure for the mean Residence statistic. Data associations can be either assigned to the current property value, or to one of the statistical parameters, depending on status of the Statistics check box on the Data tab. Creating a Data association on top of an existing data association a data sheet will not delete the existing data association. Data associations can be deleted only by the Data associations manager utility.



ations	sum	mean	variance	minimum
3	3.	1.	0.	
6	3	0.5	0.25	
6	3.	0.5	0.25	
0				
1				
1				
0				

Data associations behave differently for the Current parameter of the Residence property of server and link objects. A data association for the current value displays the residence time of the last entity removed from storage in the server, although the current parameter denotes the total residence time of all entities presently stored in the object. A data association of the Pending parameter does display the total residence time of all resident entities.

Data associations for attribute components can only be created in the *Reset* status of a simulation. For the association to become effective, an entity must be assigned to it during runtime, by the `AttributeEntity` scripting procedure of the data association.

8.4 Scripting references

Cell values in the embedded Workbook can both be read and written with the scripting command `CellValue`. Repetitive data exchange with a spreadsheet through scripting may decrease the simulation speed significantly. The speed reduction may be prevented by application of the **Use read cache** item of the Spreadsheet preferences.

8.5 Spreadsheet interaction

Renque was designed to interact with the Embedded spreadsheet in an indiscernible way. The user can generally work on the spreadsheets without noticing that it has been embedded in Renque.

References to spreadsheet cells are object-oriented. This means that a cell reference will not be affected by inserting or deleting higher rows and columns in the spreadsheet. A reference is neither affected by dragging the cell to another location on the spreadsheet. The reference is lost, however, when a column or row containing the referenced cell is deleted or when the entire sheet is deleted. The cell reference is also lost when the content of an associated cell is replaced by another cell through a drag-drop user operation. Lost cell references are preserved in the project, but are inactive because they can no longer exchange data with the spreadsheet. Scripting referencing, on the other hand is not object-oriented. The row and column arguments specified in the `CellValue` function are not adjusted if the corresponding cell is moved to another location in the sheet. A lost association reference is generally indicated in Renque by an alternative background color of the control item denoting the association and by the keyword *detached* in the association descriptor. Lost property associations cast a message to the Runtime error viewer when a new simulation is started, but lost data associations do not. By default, a warning is displayed when the cell reference of a spreadsheet association is broken by a spreadsheet operation. Continuous verification may be disabled by the **Skip reference verification** item of the Spreadsheet preferences.

When the simulation is started from the *Reset* status, the validity of all assigned property associations are verified. If a cell value is not suitable to its associated property, a runtime error is raised, and for link and server objects the associated property is assigned its default value. When the simulation is continued from the *Paused* status this verification with runtime error casting is performed for cell values of property associations that were modified while the simulation was paused. However. in that case the property is not assigned its default value, but keeps the value it had before the change. The associated object properties are also responsive to cell changes made while a simulation is running. The effect of cell value changes during a simulation run are the same as for the *Paused* status.

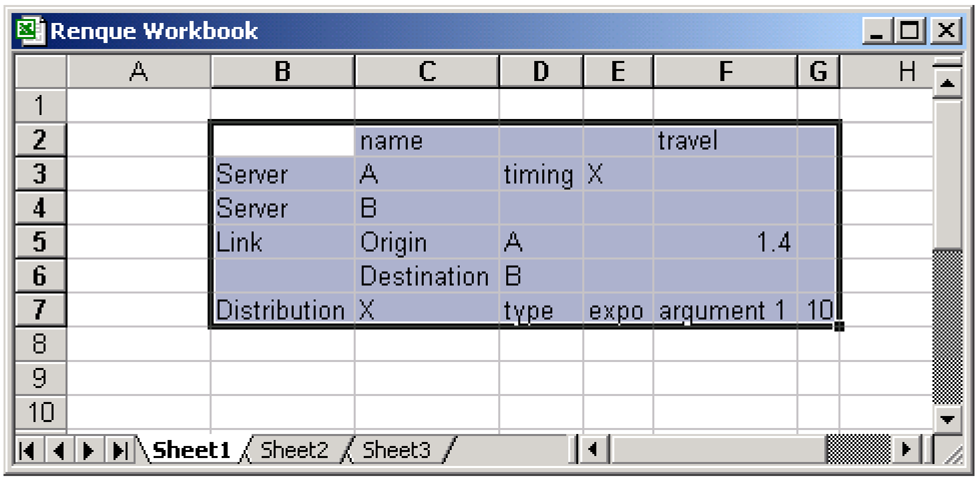
The embedded workbook is automatically saved in the project file. Copies of the embedded workbook may be saved to a separate file by the **Save** command on the File menu of the Excel application's window. Similarly, an embedded workbook may be replaced with another, previously saved workbook by the **Open** command on the File menu of Excel. When the embedded workbook is replaced, existing cell references are transferred to the new workbook on the basis of sheet name and row and column numbers.

In case *Microsoft Excel* cannot load the workbook contained in a project file, for example because of conflicting Excel versions, it may still be extracted from the project file by the **Extract spreadsheet file** command on the File menu of the Main window. This command saves the workbook contained in the project file to disk, after which it can be converted manually into a format that can be opened by the installed Excel version. The converted workbook file may then be re-embedded in the project while preserving the data associations.

8.6 Spreadsheet import

The Spreadsheet import feature allows import of objects and components from a spreadsheet. Execution of the **Spreadsheet import** command of the Edit menu of the Main window results into creation of objects and components governed by keywords and value entries in the selected cell range of the Embedded spreadsheet. Both server and link objects may be created in this way, as well as layers and variable, attribute and distribution components.

The import process is controlled by keywords. The object type to be created is specified by a primary keyword in the leftmost column of the selected cell range. Properties of the created items are specified by secondary keywords in the other columns of the selected cell range. Secondary keywords may be supplied either on row with an object type keyword, together with a value entry in the adjacent cell to the right, or in a header row, with a value entry in a lower cell in the same column. The figure below demonstrates an example of the spreadsheet import format.



	A	B	C	D	E	F	G	H
1								
2			name			travel		
3		Server	A	timing	X			
4		Server	B					
5		Link	Origin	A		1.4		
6			Destination	B				
7		Distribution	X	type	expo	argument 1	10	
8								
9								
10								

In this example two servers named A and B, a connecting link and a distribution component named X are created. The Timing property of server A is assigned distribution component X, which is of type exponential with mean 10. The Travel time property of the link is assigned a value 1.4. Import of objects and components from a spreadsheet assigns numerical values to properties by Property association, where appropriate.

Secondary keyword entries on a header row apply to all lower cells of the column, provided a primary keyword is specified in the leftmost column. Secondary keyword entries on an object row apply only to the adjacent cell to the right-hand side and overrule any keyword given on a header row. All rows beneath a row with a specified primary keyword can be used to assign properties by secondary keywords, provided the cell of the leftmost column of the lower rows are left empty. All invalid and inappropriate value entries are ignored and only the first valid incident of secondary keyword/value combination is applied.

Imported servers are arranged automatically on the Renque Worksheet. The first server created is positioned on the last Worksheet location clicked by the mouse. After creation of a server object, by default the cursor position is moved horizontally to the next line for which no overlap of the server picture with the previous occurs. The default line distance is 150% of the default server picture width.

The arrangement of created server objects is adaptable with spacing keywords. The secondary keywords *line feed* and *column feed* cause the cursor to respectively move vertically and horizontally by a specified number of lines. The keyword *new row* causes the cursor to move to the initial horizontal position and vertically by a specified number of lines. These keywords have a default value 1 for the number of lines moved and accept any integer value. They may also be applied in conjunction with the primary keyword *server*, in which case the corresponding cursor movement is applied prior to creation of the server object. The line spacing may be adjusted using the *column width* and *row height* keywords, for which values must be supplied in pixel units.

Keywords are case insensitive and identical to the corresponding property name. The table below provides a complete list of the available keywords and their abbreviated aliases.

primary	***secondary***	***secondary aliases***
Server	name	
	method	mthd
	x-position	xpos, x-pos
	y-position	ypos, y-pos
	picture	pict
	timing	timi, delay
	capacity	capa
	priority	prio
	shielding	shie
	layer	laye, layr
	caption	capn
	collect rule	collr,crule
	dispatch rule	dispr, drule
	passive rule	passr, prule
	allocation rule	allr, arule
	linkto	linkt
	linkfrom	linkf
	disabled	disa
	integrated	intg
	certified	cert
	bonding	Bond
	premature	prem
	disordered	diso
	discrete	disc
	uniting	unit
	revoking	revo
	preemptive	pree
	abortive	abor
	interruptive	inte
Link	origin	orig
	destination	dest
	originindex	oindx
	destinationindex	dindx
	travel	trav
	layer	laye, layr
	collect weight	collw, cwei

	dispatch weight	dispw, dwei
	departures	depa
	batch	batc
	excess	exce
	required	requ
	mandatory	mand
	solitary	soli
	suspending	susp
	claiming	clai
	uniting	unit
	upstream buffering	upst
	overflow recipient	over
	expiration recipient	expi
	escort	esco
	independent	inde
	initializing	init
	completing	comp
	tracking	trac
Distribution	name	
	distribution function	distf, dfunc
	parameter 1	param1, prm1, prm 1, parameter1
	parameter 2	param2, prm2, prm 2, parameter2
	parameter 3	param3, prm3, prm 3, parameter3
	parameter 4	param4, prm4, prm 4, parameter4
Attribute, Variable	name	
	default value	defav , dval, default, defval
Layer	name	
	color	colo, col
Spacing	new row	newr, nrow, crlf
	line feed	linef, lfee, lf
	column feed	coluf, cfee, cf
	column width	coluw, cwid, cw
	row height	rowh, rhei, rh
Header		

The server keywords *x-position* and *y-position* allow positioning of a created server object at a specified location on the viewport. The values supplied determine the position from respectively the left and top viewport edges in pixel units.

The keywords *new row*, *line feed* and *column feed* can be supplied without value specification, in which case a value unity is applied.

The server keywords *collect rule*, *dispatch rule* and *passive rule* are applied in conjunction with a range of value keywords. For the *collect rule* and *dispatch rule* keywords the corresponding value keywords are *cycle*, *random*, *probability* and *port order*; for the *passive rule* keyword the value keywords are *FIFO*, *random* and *LIFO.*

The server keywords *linkto* and *linkfrom* allow creation of a link connected to the server being created. The value supplied to these keywords must be a valid server name. Any subsequent secondary link keyword supplied on the same spreadsheet row is applied to the created link, until another secondary server keyword is encountered.

The primary keyword *Header* is applied to renew the set of assigned secondary header keywords. Application of this keyword erases all previously assigned header keywords. For the top header row it can be omitted. Any secondary keyword may be applied as header keyword, with the exception of the spacing keywords *column width* and *row height*.

9 Tools & utilities

Renque has a number of utilities that assist the user in project construction and review:

- Statistical analysis
- Presentation properties
- Alignment utility
- Search utility
- Runtime error viewer
- Event viewer
- Window arrangement utility
- Preferences
- Paste special utility
- Font selection utility

9.1 Statistical analysis

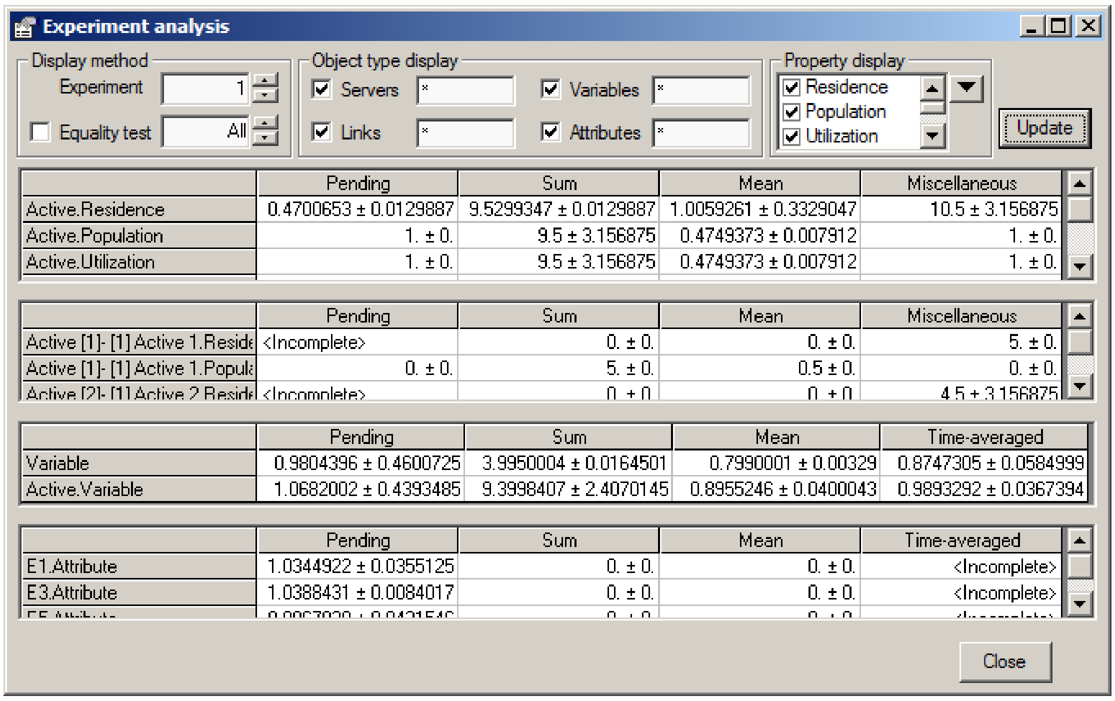
The Statistical analysis tool is an instrument used to examine simulation data recorded for multiple replications. The tool is accessed by the **Statistical analysis** item on the Tools menu of the Main window. It is available only if the simulation run has at least two completed replications.

Different replications of a simulation that employs distribution components yield different results, because each replication uses a different set of random numbers. In general, the value of a simulation data parameter, averaged over all performed replications, approaches the “true” parameter value, as the number of replications grows. Because the actual number of replications for a simulation run is limited, there is always some uncertainty about evaluation of simulation results with stochastic properties.

In order to assess the uncertainty level, Renque can estimate a confidence interval for data parameters, on the basis of the Student’s t-distribution. The confidence interval represents a value range which contains, with a specified probability, the true parameter value. The probability for this confidence interval is set by the **Confidence level** item in the Date Preferences. The default value is 0.95. The analysis method applied requires the parameter value to be normally distributed in the replications population. However, there are many evidence that suggest that the method is quite robust with respect to deviations from the Normal distribution type in the sample distribution. Confidence intervals can also be plotted in graph servers, using the *Confidence diagram* Style value.

Renque can calculate parameter confidence ranges for all experiments performed. It can also determine the confidence range of the difference of a parameter value between two experiments. The latter is useful to test the hypothesis that a simulation parameter has the same value for different experiments.

The console presents the calculated intervals in four separate data sheets for different object and component types. The set of framed control items at the top of the window determine which data are displayed. The **Update** button at the right side of the window refreshes the data sheets after changes have been made to the control items in the frames.


Experiment analysis

Display method: Experiment 1; Equality test [ ] All

Object type display: [✓] Servers *; [✓] Links *; [✓] Variables *; [✓] Attributes *

Property display: [✓] Residence; [✓] Population; [✓] Utilization

	Pending	Sum	Mean	Miscellaneous
Active.Residence	0.4700653 ± 0.0129887	9.5299347 ± 0.0129887	1.0059261 ± 0.3329047	10.5 ± 3.156875
Active.Population	1. ± 0.	9.5 ± 3.156875	0.4749373 ± 0.007912	1. ± 0.
Active.Utilization	1. ± 0.	9.5 ± 3.156875	0.4749373 ± 0.007912	1. ± 0.

	Pending	Sum	Mean	Miscellaneous
Active [1]- [1] Active 1.Reside	<Incomplete>	0. ± 0.	0. ± 0.	5. ± 0.
Active [1]- [1] Active 1.Popul	0. ± 0.	5. ± 0.	0.5 ± 0.	0. ± 0.
Active [2]- [1] Active 2.Reside	<Incomplete>	0. ± 0.	0. ± 0.	4.5 ± 3.156875

	Pending	Sum	Mean	Time-averaged
Variable	0.9804396 ± 0.4600725	3.9950004 ± 0.0164501	0.7990001 ± 0.00329	0.8747305 ± 0.0584999
Active.Variable	1.0682002 ± 0.4393485	9.3998407 ± 2.4070145	0.8955246 ± 0.0400043	0.9893292 ± 0.0367394

	Pending	Sum	Mean	Time-averaged
E1.Attribute	1.0344922 ± 0.0355125	0. ± 0.	0. ± 0.	<Incomplete>
E3.Attribute	1.0388431 ± 0.0084017	0. ± 0.	0. ± 0.	<Incomplete>
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

The controls on the console have the following functions:

Display method

Sets the data display scope. The **Experiment** control item selects the experiment number for the data set displayed on the console. If the value *All* is selected in the Experiment text field, data are displayed for all experiments on different rows of the data sheets on the console.

By default, confidence intervals are displayed for absolute parameter values. Application of the **Equality test option** allows for display of confidence intervals for the difference of parameters, between experiments. Checking this option switches data display to parameter differences between a reference experiment and a target experiment. The reference experiment number is set in the **Experiment** field. The target experiment number is set in the **Equality test** field. If this text field has the value *All*, equality test intervals are shown for all experiments other than the reference experiment on different data sheets rows. The option is available only if multiple experiments have been concluded in the simulation run.

Object type display

The controls in this frame allow hiding specific objects in the data sheets by name. It is also possible to hide each of the four data sheets completely. The check box values determine wither or not the corresponding data sheet is shown. The adjacent text fields filters out sheet rows by a name pattern matching key, using Window's common wildcard characters.

Property display

The server and link data sheets show parameter data for respectively 7 and 2 recorded object properties on separate sheet rows. Unchecking an item removes the corresponding rows from the data sheets.

Data sheets

The four data sheets present a set of 4 statistical parameters for recorded property data. The composition of the data sheets is similar the data sheet composition for recorded statistics on the Data tab of the Object properties console. The statistical parameters are organized in columns. The parameter name is indicated in the category row of the sheet. The recorded object properties are organized in rows. The server data sheet has 7 object property rows for each server. The link data sheet has 2 object property rows for each link. The category column of the server and link data sheets list the server or link name, followed by a dot and the property name. The variable and attribute data sheets have only one row for each data component, which represents the Value property of a variable or entity attribute. The category column of the variable data sheet lists the variable name, preceded for local variables by a dot and the server or link name. The category column of the attribute data sheet lists the attribute name, preceded by a dot and the entity Identifier.

By default, the cells on the data sheets present the intervals by the mean value and the interval half-width, separated by the ±-sign. The reporting style of the data sheets is set by the **Report style** command in the pop-up menu of the data sheets. If the *Range* item is selected, the interval boundaries are displayed, separated by the character combination “<−>". For the Equality test display mode, selection of the *Parity item* will display “x” if the confidence interval includes the value zero, or “-” if zero is not included.

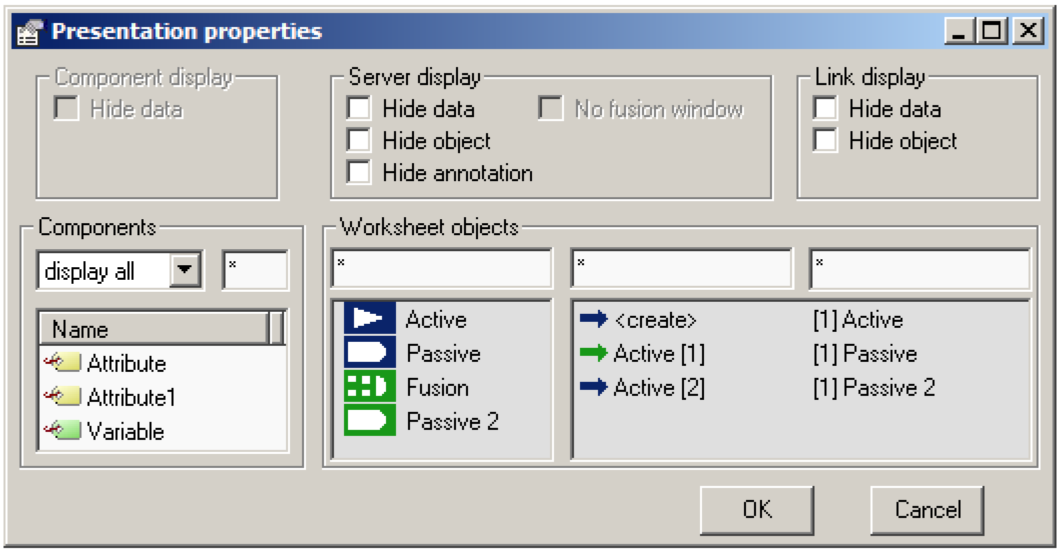
9.2 Presentation properties

The Presentation properties console controls the display properties of the Renque presentation file for a project. The console window is opened by the **Presentation properties** command on the Tools menu. Operation of the console is similar to the Object properties console.

Context worksheet

The window can be opened from the Main window and from a Fusion window. The window from which the console is opened determines the Context worksheet of the console. For server and link objects, the console only displays properties of objects that have the selected state in the Context worksheet.

The Worksheet objects frame, located at the bottom-right of the console window, catalogs the objects contained in the Context worksheet. This frame contains the Server and Link browses. The selection state of objects cannot be changed in the browsers.


Presentation properties

Component display: ☐ Hide data

Server display: ☐ Hide data ☐ No fusion window ☐ Hide object ☐ Hide annotation

Link display: ☐ Hide data ☐ Hide object

Components: display all, *

Name
Attribute
Attribute1
Variable

Worksheet objects: *, *, *

Active	<create>	[1] Active
Passive	Active [1]	[1] Passive
Fusion	Active [2]	[1] Passive 2
Passive 2		

The Components frame, at the bottom-left of the window, contains the Component repository, which presents attribute and variable components to which the Display data option is applied. Component objects can be selected and unselected in the repository. The console displays component properties of selected items in the repository.

At the top of the window are three frames that control the Presentation properties of the objects selected in the console. These properties are:

Hide data

Prevents the display of objects in the data sheets on the Data tab of the Object properties console.

Hide object

Prevents the display of server and link objects in the Worksheet.

Hide annotation

Prevents the display of server Annotations in the Object properties console.

No Fusion window

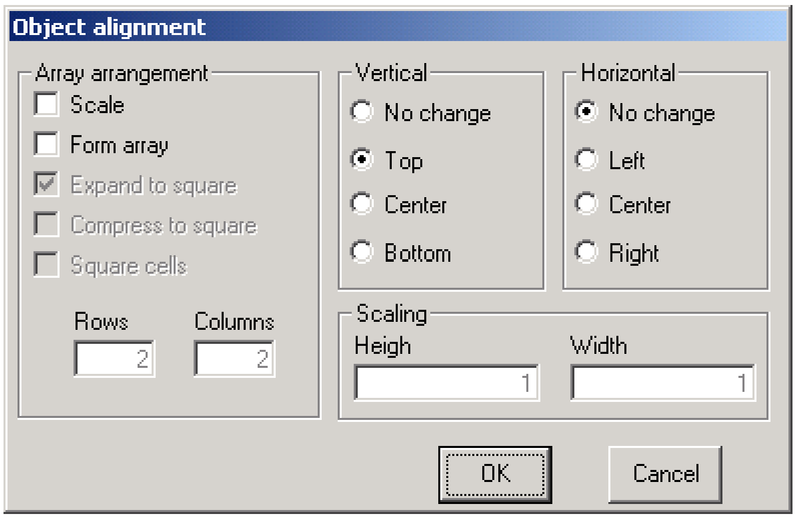
Prevents Fusion windows from being opened for fusion servers.

9.3 Alignment utility

The alignment utility allows the user to align the position of servers on a Worksheet. It is activated by clicking the **Align objects** item of the Format menu. The utility can be opened from the Main window and from a Fusion window. The alignment only affects servers selected in the Worksheet of the window from which the utility was opened.

When the alignment utility is activated the alignment utility window appears and the Main window and all Fusion windows are disabled until the alignment utility is closed.

Servers are aligned by the bounding box of their picture display element, if visible on the Worksheet. If the server picture is not visible, servers are aligned by the bounding box of the caption. If neither the picture not the caption are visible servers are aligned by the center point of the picture.



Object alignment

Array arrangement
- [ ] Scale
- [ ] Form array
- [✓] Expand to square
- [ ] Compress to square
- [ ] Square cells

Rows: 2 Columns: 2

Vertical: No change [✓ Top] Center Bottom

Horizontal: [✓ No change] Left Center Right

Scaling
Heigh: 1 Width: 1

The alignment utility window has four frames. The frames named horizontal and vertical determine the alignment orientation. The Array arrangement frame enables alignment organized in rows and columns. The Scaling frame allows independent scaling of the arrangement in the horizontal and vertical direction.

No change

No changes are made to the server positions in either the horizontal or vertical direction.

Left, Center, Right

Aligns the horizontal position of respectively the left-most edges, the center and right-most edges of the selected server pictures in line with respect to the server object last selected by clicking. If all objects were selected by a rectangular sweep the alignment reference is the horizontal center of the selection.

Top, Center, Bottom

Has the same function as the left, center and right options but aligns the vertical position of the selected objects by respectively the top, center and bottom edges.

Scale

Scales the realignment span by horizontal and vertical scaling factors as defined in the Scaling frame on the window

Form array
If the Form array property is applied the alignment algorithm will organize the positions of a scattered set of selected servers into the shape of a matrix.

Expand to square
Forces the arrangement into a square array increasing either the width or the height of the selected servers collection, depending on the aspect ratio of the scatter. Not available if the rows or columns value is equal to unity.

Compress to square
Forces the arrangement into a square array decreasing either the width or the height of the selected servers collection, depending on the aspect ration of the scatter. Not available if the rows or columns value is equal to unity.

Square cells
Forces the arrangement into array with square cells. This property is available only if either the expand to square or the Compress to square property is applied. If the Expand to square property is applied either the width or height of the selection span is increased to obtain equal column width and row height of the array formed.

Rows
Number of rows formed by the alignment. Default value: 2. Possible values: Integer number greater than zero. If the value 1 is applied the result of the alignment in vertical direction is identical to the result obtained without array formation.

Columns
Number of columns formed by the alignment. Default value: 2. Possible values: Integer number greater than zero. If the value 1 is applied the result of the alignment in horizontal direction is identical to the result obtained without array formation.

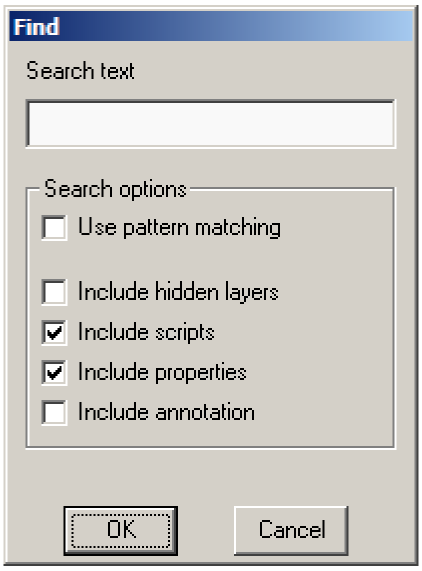
Height
Changes the height of the selection span by the factor indicated. Not available if the Expand to square or Compress to square property is applied. If the height factor is applied in conjunction with the expand or Compress to square properties, the selected servers are repositioned with respect to the middle of the selection span.

Width
Sets the width of the selection span by the factor indicated. Not available if the Expand to square or Compress to square property is applied.

9.4 Search utility

The search utility can be used to search for server objects in a Worksheet. It is activated by the **Find** item of the Edit menu, or by pressing the shortcut key combination **<ctrl>F** in the Worksheet. The utility can be opened from the Main window and from a Fusion window. The search domain contains only servers in the Worksheet of the window from which the utility was opened. The utility searches for a user-specified string. All objects that satisfy the search criterion are selected in the Worksheet and may subsequently be viewed and edited.

When the utility is activated the Find window appears and the Main window and all Fusion windows are disabled until the search utility is closed. The utility window has a **Search text** field, where the search string is entered and the Search options frame. The frame contains a number of check boxes, which determine the search domain and method. The search domain always includes server names.



Use pattern matching
Enables pattern matching using the Window's common wildcard characters.

Include hidden layers
Expands the search domain to include hidden layers. Any layer that contains an object that matches the search criterion will be unhidden.

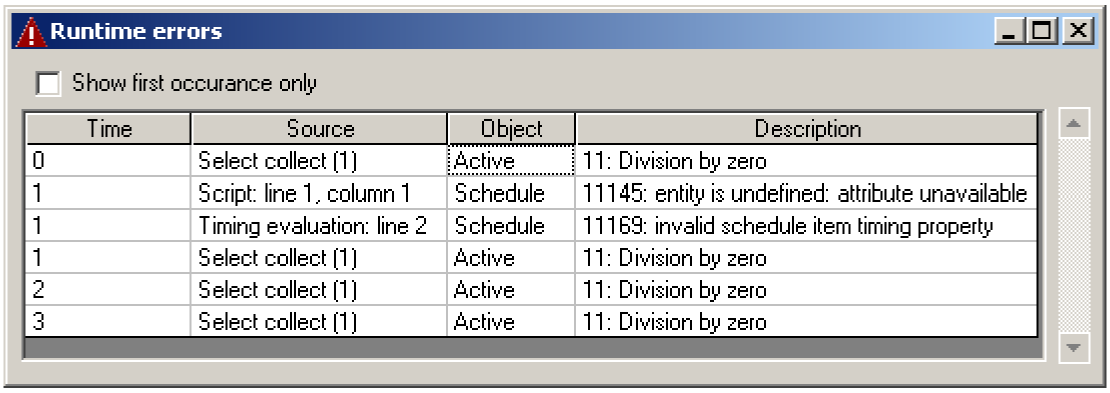
Include scripts
Expands the search domain to include incident scripts.

Include properties
Expands the search domain to include values of server properties. Use the key string <*Void*> to search for objects that have been assigned the *Void* property.

Include annotation
Expands the search domain to include server annotation text.

9.5 Runtime error viewer

The runtime error viewer utility displays a listing of runtime error messages returned by executed incident and schedule scripts and error messages resulting from invalid spreadsheet cell associations. The window is opened from the **Runtime errors** item on the Tools menu.



Time	Source	Object	Description
0	Select collect (1)	Active	11: Division by zero
1	Script: line 1, column 1	Schedule	11145: entity is undefined: attribute unavailable
1	Timing evaluation: line 2	Schedule	11169: invalid schedule item timing property
1	Select collect (1)	Active	11: Division by zero
2	Select collect (1)	Active	11: Division by zero
3	Select collect (1)	Active	11: Division by zero

The error messages listing is displayed in a sheet with four columns:

• **Time**	Simulation time of the error occurrence.
• **Object**	Name of the object that caused the error. In case the error was caused by an invalid spreadsheet cell association the object column displays the associated object name.
• **Incident**	Displays the incident and the script sequence number separated by a dash. If the runtime error object is a schedule component, the event column displays the row and column number of the schedule item, which has caused the error to occur. In case the error was caused by an invalid spreadsheet cell association the event column indicates the property involved.
• **Description**	Displays the error number and description. Error numbers in the range 11000 to 12000 represent Renque specific errors. Other error numbers refer to VBscript errors.

Show first occurrence only

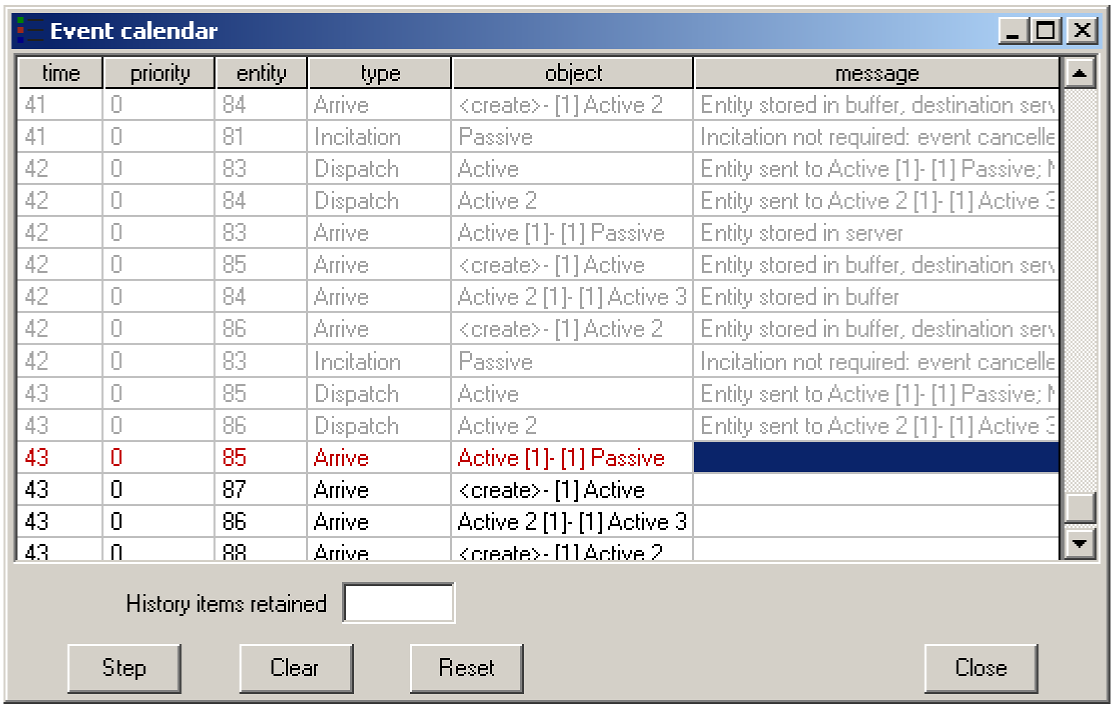
This property hides all but the first item of error messages that differ only by the time property.

Double-clicking a cell in the object column of the error message sheet results into selection of the corresponding object in the Worksheet where it is located, provided the event object is a server or link object. If the error object is a component, the item is selected in the Component repository of the Object properties console, provided the console is open. The **Select objects** item of the pop-up menu of the error messages sheet selects the error objects of all selected rows in the sheet.

The runtime error viewer window may remain open while a simulation is running. In that case the listing is updated each time an error occurs.

9.6 Event viewer

The event viewer utility displays the Event calendar listing. It is activated by the **Event viewer** item on the Tools menu. The utility is displayed in a separate window, which contains the listing sheet and several additional controls. The events are organized in rows in order of event execution. The text color of the sheet rows depends on the event status. The next event is displayed in red, future events are displayed in black, and events that have been executed are displayed in green. The event listing does not display events that were executed before the utility was activated.



time	priority	entity	type	object	message
41	0	84	Arrive	<create>- [1] Active 2	Entity stored in buffer, destination serv
41	0	81	Incitation	Passive	Incitation not required: event cancelle
42	0	83	Dispatch	Active	Entity sent to Active [1]- [1] Passive; N
42	0	84	Dispatch	Active 2	Entity sent to Active 2 [1]- [1] Active 3
42	0	83	Arrive	Active [1]- [1] Passive	Entity stored in server
42	0	85	Arrive	<create>- [1] Active	Entity stored in buffer, destination serv
42	0	84	Arrive	Active 2 [1]- [1] Active 3	Entity stored in buffer
42	0	86	Arrive	<create>- [1] Active 2	Entity stored in buffer, destination serv
42	0	83	Incitation	Passive	Incitation not required: event cancelle
43	0	85	Dispatch	Active	Entity sent to Active [1]- [1] Passive; N
43	0	86	Dispatch	Active 2	Entity sent to Active 2 [1]- [1] Active 3
43	0	85	Arrive	Active [1]- [1] Passive	
43	0	87	Arrive	<create>- [1] Active	
43	0	86	Arrive	Active 2 [1]- [1] Active 3	
43	0	88	Arrive	<create>- [1] Active 2	

The sheet has seven columns each displaying a specific property of the event:

• **Time**	Simulation time of the event.
• **Priority**	Priority value of the event.
• **Entity**	Entity identifier number of the event. If no entity is defined for an event the cell is left blank. Note that after deletion of the entity its identifier may be re-assigned to a newly created entity.
• **Object**	Name of the Event object. The Event object can be a server or link object or a schedule component. If no Event object is defined for an event the item is left blank.
• **Event**	Description of the event type.
• **Message**	Displays a message returned by executed events denoting the event result.

If the mouse is clicked on the top row of the sheet the listing is sorted by the content of the column on which the mouse clicked.

The window contains some additional controls to manage the display properties. These are:

Step
Executes the current event each time the button is pressed. The event listing is updated after execution of the event. The button is disabled when a simulation is running.

Clear
Removes all events that have been executed.

Reset
Recovers the original display order of the listing.

History items retained
Maximum number of executed event items to be displayed in the listing. If the text field is left empty the listing will display all current, future and executed events.

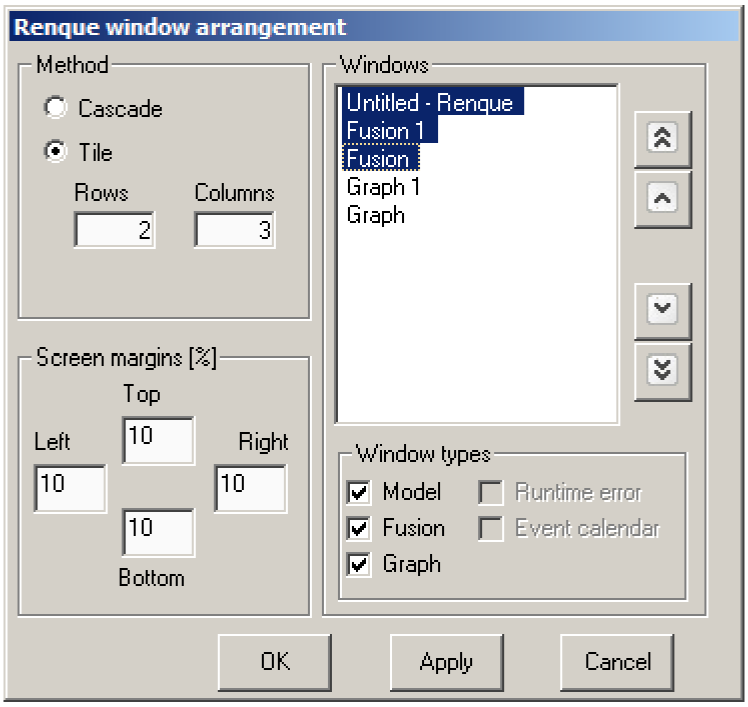
Double-clicking a cell in the object column of the event message sheet results into selection of the corresponding object in the Worksheet where it is located, provided the event object is a server or link object. If the event object is a component, the item is selected in the Component repository of the Object properties console, provided the console is open. The **Select objects** item of the pop-up menu of the event sheet selects the event objects of all selected rows in the sheet.

The event viewer may remain open while a simulation is running. In that case the listing is updated as the simulation proceeds.

9.7 Window arrangement utility

The window arrangement utility can be used to arrange the various windows opened by a running instance of Renque on the monitor screen. It is activated by the **Arrange Windows** item of the Window menu.

The utility window contains three frames. The Method frame determines the way the window rearrangement operation is carried out. The frame labeled *Windows* controls which windows are rearranged and determines the repositioning order of the windows. The Screen margins frame defines a screen area for placement of the rearranged windows. On a system with multiple monitors the windows are placed on the monitor on which the utility window is displayed.


Renque window arrangement

Method: ( ) Cascade [● Tile]
Rows: 2
Columns: 3

Screen margins [%]: Top 10, Left 10, Right 10, Bottom 10

Windows:
Untitled - Renque
Fusion 1
Fusion
Graph 1
Graph

Window types: [✓] Model, [✓] Fusion, [✓] Graph, [ ] Runtime error, [ ] Event calendar

Method

Defines the arrangement method. Application of the **Cascade** option stacks the windows in a such manner that overlap of the title bar of the rearranged windows is minimizes. The **Tile** option arranges the windows in as many **Rows** and **Columns** as specified in the two associated text fields, in such a way that no window overlaps any other window. For both options the windows are uniformly resized.

Screen margins

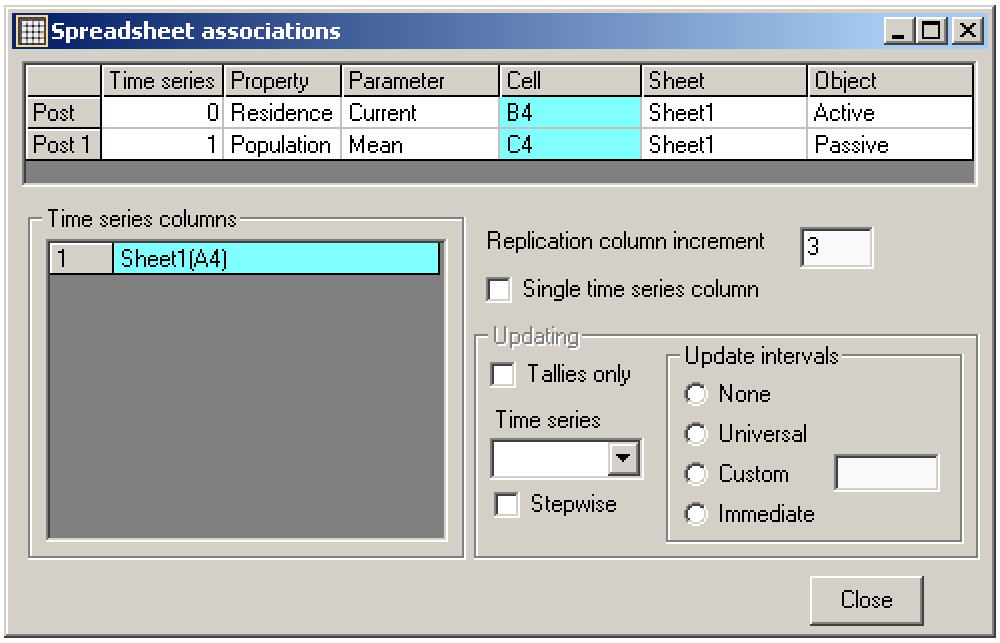
Defines the margins on all four edges of the target area in percentages of the screen height or width.

Windows

The list in the Windows frame displays the name of each window subjected to the rearrangement procedure. Only windows of the types checked in the Window types sub-frame appear in the list. The list is rebuilt every time one of the checkbox values changes. The order of the listed items can be modified with the adjacent **Arrow buttons**. Pressing the **Delete key** removes selected items from the list. Minimized or maximized windows and not included because they can not be rearranged.

9.8 Data association manager

This utility manages data associations. It is opened by the **Data associations manager** command on the Tools menu. The utility allows the properties of all data associations in the project to be viewed and modified.


Spreadsheet associations

	Time series	Property	Parameter	Cell	Sheet	Object
Post	0	Residence	Current	B4	Sheet1	Active
Post 1	1	Population	Mean	C4	Sheet1	Passive

Time series columns

1	Sheet1(A4)

Replication column increment: 3

Single time series column: ☐

Updating

Tallies only: ☐

Time series:

Stepwise: ☐

Update intervals: None / Universal / Custom / Immediate

The **Data associations grid** at the top of the window presents the data association properties, organized in columns. The column labeled **Object** displays the name of the data association object. The columns labeled **Property** and **Parameter** show respectively the statistical property and statistical parameter of the data association. The target spreadsheet cell is indicated in the Columns labeled **Sheet** and **Cell.** The last column marks the index of the below-mentioned Time series column of the data association. The value 0 in this last column indicates that no time series column has been assigned.

A single mouse click on a the title row renders the listing order alphabetically with respect to the column that was clicked. Clicking the title row again on the same column reverses the order.

Time series columns

The Time series columns frame contains a list of all defined time series for the project. Time series are used to post multiple observations of statistical properties with the observation times to a spreadsheet. The spreadsheet cell displayed in the list represents the top cell of the range to which simulation time observations are written. The simulation time of the first observation of a data association that uses the time series is written to this cell. The simulation time of all subsequent observations are written consecutively to the cells beneath this first cell. Time series items can be added to and deleted from the list by a pop-up menu that appears after clicking on the list with the right mouse button. Time series do not have user-controlled properties other than the top spreadsheet cell displayed in the list.

Replication column increment

This property determines the spreadsheet column offset for simulation replications. The zero default value causes spreadsheet posts to be overwritten by subsequent replications. If a value greater than zero is specified in the adjacent text field, the column number of a data association is incremented by the number specified, for each additional replication. The replication column increment is a property of the project and affects all spreadsheet posts.

Single time series column
Application of this option omits the above-mentioned Replication column increment for time series columns and all data associations with assigned time series. If applied, data are written to the same column for all replications, separated by an empty row.

Overwrite experiments
By default, replication column increments continue for new experiments. Application of this option overwrites all posted data when a new experiment starts.

The control items in the Updating frame regulate the frequency of data export to the spreadsheet for data associations. The properties displayed in the frame represent the properties of all items selected in the grid. Where the selection has a non-uniform value, the keyword <various> is displayed in text fields and check boxes are grayed out. Changes made to the control items in the frame apply to all data associations selected in the grid.

Tallies only
The spreadsheet values of data associations can be updated at arbitrary moments in the simulation, thus providing a snapshot of the state of the simulation. Application of this option restricts spreadsheet updates to parameter changes ensuing a change in the state of the data association object that would also invoke an observation recording. The option affects only the Current and Pending statistical parameters. For other parameters, the option applies inherently, as well as for data associations with an assigned time series.

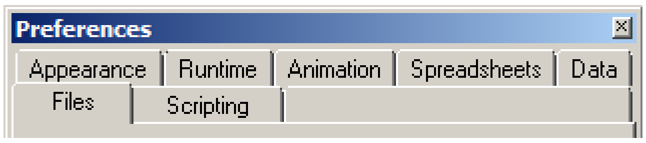
Time series
Assigns a Time series item to the selected data associations. The number indicated in the control refers to the sequence number of the items in the Time series columns.

Stepwise
By default, time dependent data points are written to the spreadsheet individually. If this option is applied the spreadsheet is supplied with intermediary points such that curves represented by the data set exhibit a stair stepping pattern. Application of this option is set automatically when creating data associations for properties that are stepwise by nature. The check box is disabled if no time series has been assigned.

Update frequency
The Update frequency options determine the updating frequency of a spreadsheet post during a simulation run. If the default option **None** is selected, spreadsheet posts are updated only when a simulation replication is paused or terminated. Application of one of the other options in the Updating frame will cause the spreadsheet to be updated during simulation runs as well. Selection of the *Collective* value produces spreadsheet updates at intervals determined by the **Collective update** item of Runtime preferences.. The **Custom** option implements updates with a specific frequency for a particular data association,. The custom frequency is specified in seconds real-time in the adjacent text field, which accepts any positive non-zero number. The **Immediate** option forces the spreadsheet to be updated for every change of the data association property. The latter should be used with caution, as it may drastically decrease the simulation speed.

9.9 Preferences

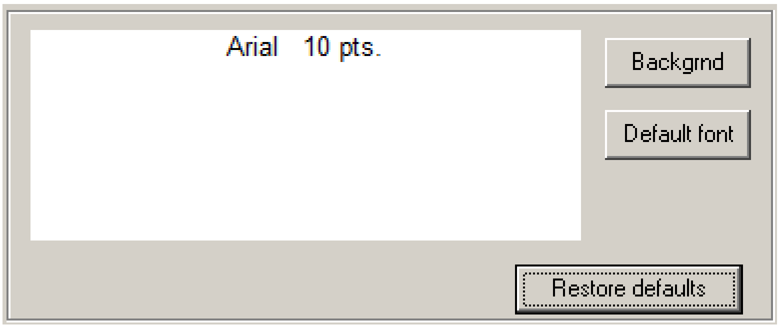
The application and project preferences are set by the **Preferences** item of the Edit menu. Selecting a tab item at the top of the console displays the corresponding category.



The upper tab row represents project properties, which are saved with the project in the project file. The lower row represents application properties. The available preferences categories are:

Appearance

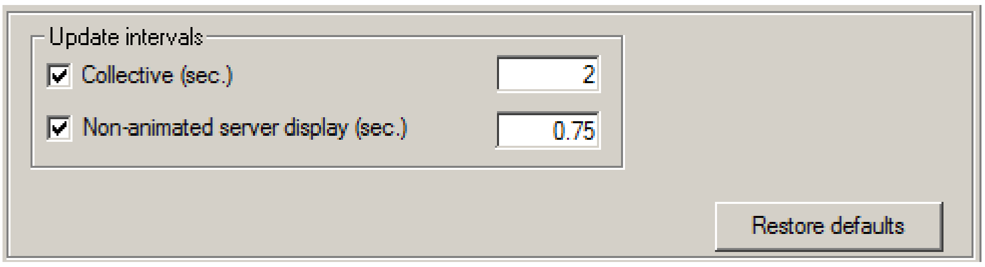
Enables modification of the default font and the Worksheet background color.



The preview area on the tab displays the default font and the background color of the Worksheet of the Main window. The font is shown in the preview area as it appears on the Worksheet for newly created server objects at the default viewport zoom level. The **Backgrnd** button opens the background color selection utility. The **Default font** button opens a font picker tool, which allows you to change the default font.

Runtime

Determines the behavior of the application during a simulation run.


Update intervals

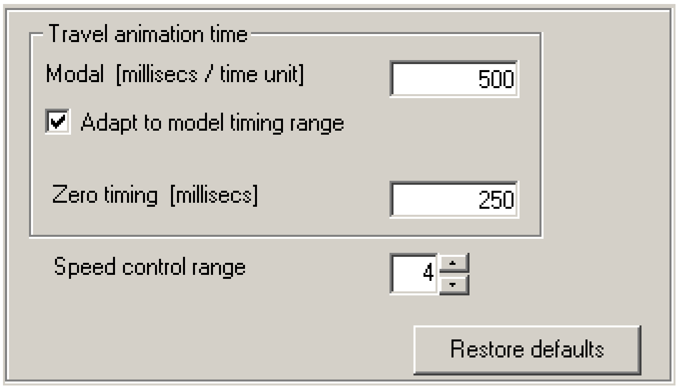
[✓] Collective (sec.) 2

[✓] Non-animated server display (sec.) 0.75

The frame labeled *Update intervals* presents preference settings that are related to the screen refresh frequency during runtime. The interval times are specified in real-time seconds in the text fields on the frame, which accept any value greater than zero. The **Collective** checkbox enables collective repainting of graph servers, and transfer of data to the embedded workbook for data associations, during a simulation run. The updates are performed only on objects that have the *Collective* value (Default) selected for the Update frequency property of graph servers, or the Update frequency property of data associations. The **Non-animated server display** checkbox enables repainting of servers on the Worksheet during a simulation run with Animation disabled. Disabling this option maximizes the simulation speed, but leaves only the messages displayed on the Status bar of the Main window as visual indication of the simulation progress.

Animation

Enables modification of the internal animation speed parameters

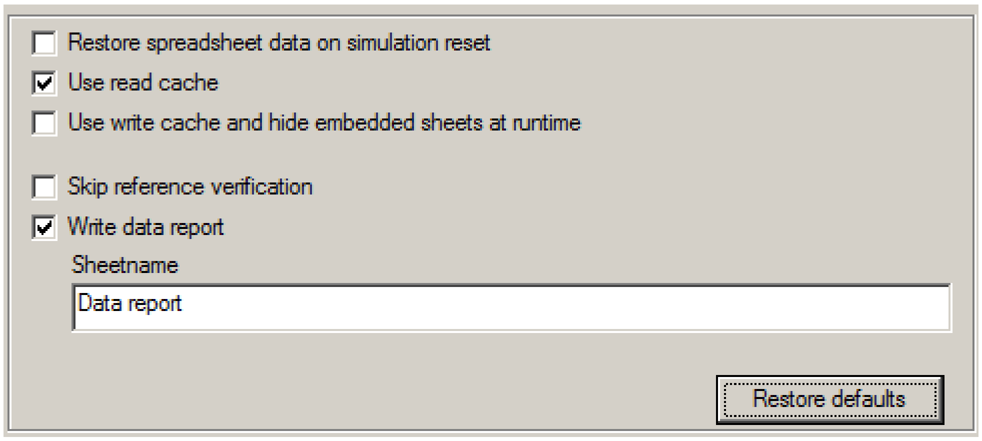


Travel animation time
Modal [millisecs / time unit] 500
[✓] Adapt to model timing range
Zero timing [millisecs] 250
Speed control range 4

The three framed controls determine the way animation speed is controlled by the Animation speed slider control. The **Modal** control defines the animation duration in real-time milliseconds per simulation time unit. The modal animation speed represents the animation speed with the slider control in the center position. If the **Adapt to project timing range** property is checked, the animation speed is adapted for the average Travel time of all link objects in the project. **Zero timing** travel animation is assigned an apparent nominal animation speed, independently. The width of speed range attained with the speed slider control is adjustable with the **Speed control range** control. The speed range number exponentially affects the speed control range width, and is limited to the integer values between 1 and 10.

Spreadsheets

Controls interaction with the Embedded workbook.



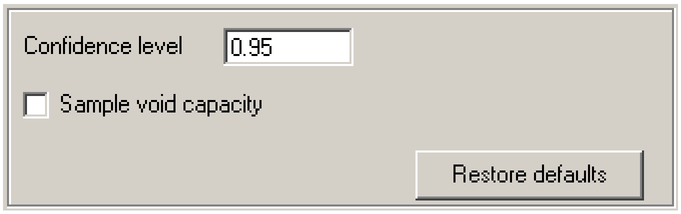
[ ] Restore spreadsheet data on simulation reset
[✓] Use read cache
[ ] Use write cache and hide embedded sheets at runtime
[ ] Skip reference verification
[✓] Write data report
Sheetname
Data report

The `CellValue` scripting command enables reading from and writing to spreadsheet cells of the embedded workbook during a simulation run. By default, values written by the `CellValue` procedure remain in the workbook after a simulation reset. If the **Restore spreadsheet data** option is applied, a simulation reset by the user will restore the reset state of the workbook by recovering its content at the simulation start. In addition, the `CellValue` procedure interacts directly with the embedded workbook by default, which is relatively slow process. Application of the **Use read cache** option creates a spreadsheet copy in memory at the start of a simulation replication and the `CellValue` procedure reads only from the memory cache. This caching method may significantly increase the simulation speed if extensive spreadsheet reading by the `CellValue` procedure is used, at the expense of more memory usage. The **Use write cache** option enables both reading and writing to the cache. Application of this option increases the simulation speed if extensive writing by the `CellValue` procedure is used. The cache writing option hides the embedded workbook and renders all Runtime spreadsheet calculations inoperative.

Checking the **Skip reference verification** option will prevent Renque from checking spreadsheet cell references for every change made to a spreadsheet. In models with a large number of property associations or data associations this verification step may hinder working in the embedded workbook. If this option is checked, verification is skipped and cell references are verified only when their function is performed. This results into virtually no interaction with an embedded workbook if the simulation project is in the *Reset* status, provided that both the Data association manager and the Object properties console are closed. The drawback is that no warning is displayed when the cell reference of a spreadsheet association is broken by a spreadsheet operation. Finally, the **Write data report** check box enables the Data report function. The name of the worksheet in the Embedded workbook to which simulation data is exported is specified in the text field labeled **Sheetname**. If the specified sheet doesn't exist, it is created.

Data

Enables modification of the data recording and data analysis methods applied.



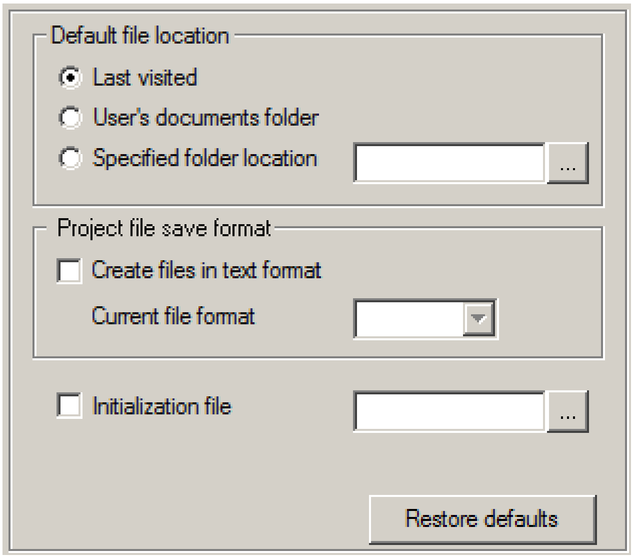
Confidence level 0.95

☐ Sample void capacity

The **confidence level** control sets the confidence interval probability value applied by the Statistical analysis tool. The **Sample void capacity** checkbox is available for simulation projects created by Renque versions earlier than 2.14 and for simulation projects saved with this option applied by newer versions. The option is provided for backward compatibility towards the statistics recording method applied to the server Capacity property. Checking this option forces the *Void* capacity property to be included in recorded statistics as an infinitely large number.

Files

The controls in the **Default file location** frame set the initial folder for the **Open** and **Save** commands of the File menu.



Default file location
(● Last visited
○ User's documents folder
○ Specified folder location

Project file save format
☐ Create files in text format
Current file format

☐ Initialization file

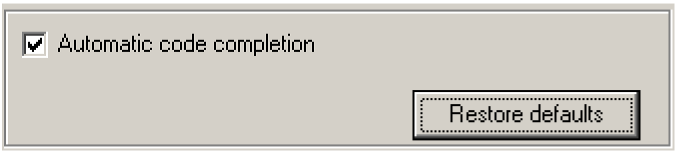
The three options are: The **Last visited** folder by Renque file operations, the **User documents folder** of the system, or a **Specified folder location**, which is typed into in the text field or selected using the browse button.

The items in the **Project file save format** frame are used to set the file format for saving Renque project files to a disk. By default, new created files are save in binary format. If the **Create files in text format** option is checked, files are saved in the text format. Such files can be edited by a text editor, whereas binary files cannot. On the other hand, binary formatted files are usually more compact for large files, and saving and reading files in binary format is faster than in text format. A text file type is recognized by the header *Renque project file,* followed by the version number of the application by which the file was written. Files read from disk are saved back in the same format. The **Current file format** Combo box permits changing the file format for a case file loaded from disk.

The **Initialization file** option allows for the selection of a Renque project file to be initially loaded for each new simulation project. The initialization file is selected using the browse button to the right of the file identifier text field. This feature can be used, for instance, to practically replace the default template set in the Toolbox with a customized set of templates.

Scripting

Controls the scripting editor properties.



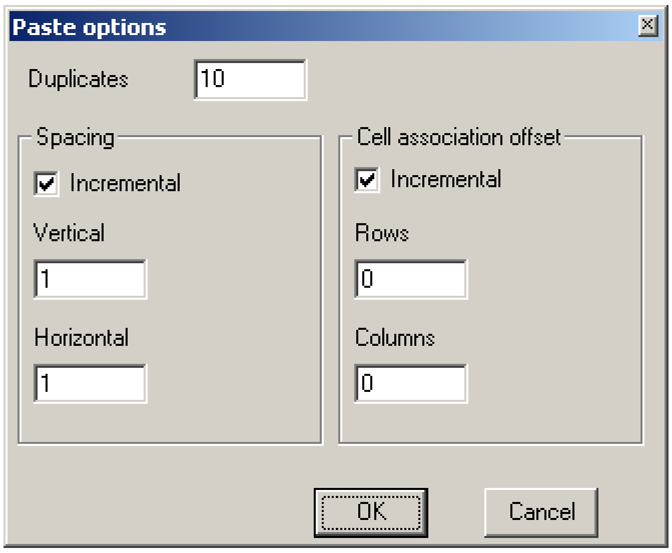
☑ Automatic code completion

If the **Automatic code completion** option is checked the Automatic code completion feature is enabled.

9.10 Paste special utility

This utility is activated by the **Paste special** item in the Edit menu, and as **pop-up menu** item on the Component repository. It is used to perform serial paste operations on Renque objects stored in the clipboard of the operating system.

The paste special dialog for the Main window and Fusion windows is shown in the figure below. When the OK button is pressed Renque server and link objects are pasted from the clipboard into the Worksheet.


Paste options

Duplicates: 10

Spacing
- [✓] Incremental
- Vertical: 1
- Horizontal: 1

Cell association offset
- [✓] Incremental
- Rows: 0
- Columns: 0

The Paste operation is affected by the values specified in the control items on the dialog window in the following ways:

Duplicates
Number of duplicates of pasted objects.

Vertical
Determines the vertical position of the pasted server objects. Any floating-point number may be applied to the associated text field. The value entered signifies the vertical distance of pasted servers to the insertion position on the Worksheet, measured in height of the default server picture. The distance is incremented for each pasted duplicate if the **Incremental** box is checked

Horizontal
Determines the horizontal position of the pasted server objects. Any floating-point number may be applied to the associated text field. The value entered signifies the horizontal distance of pasted servers to the insertion position on the Worksheet, measured in width of the default server picture. The distance is incremented for each pasted duplicate if the **Incremental** box is checked

Rows
Determines the row number offset for pasted cell associations with respect to the cell row number of the source association in the clipboard. Any positive integer number may be applied to the associated text field, with default zero value. The row number offset of the cell association is incremented for each pasted duplicate by the value specified if the **Incremental** box is checked.

Columns

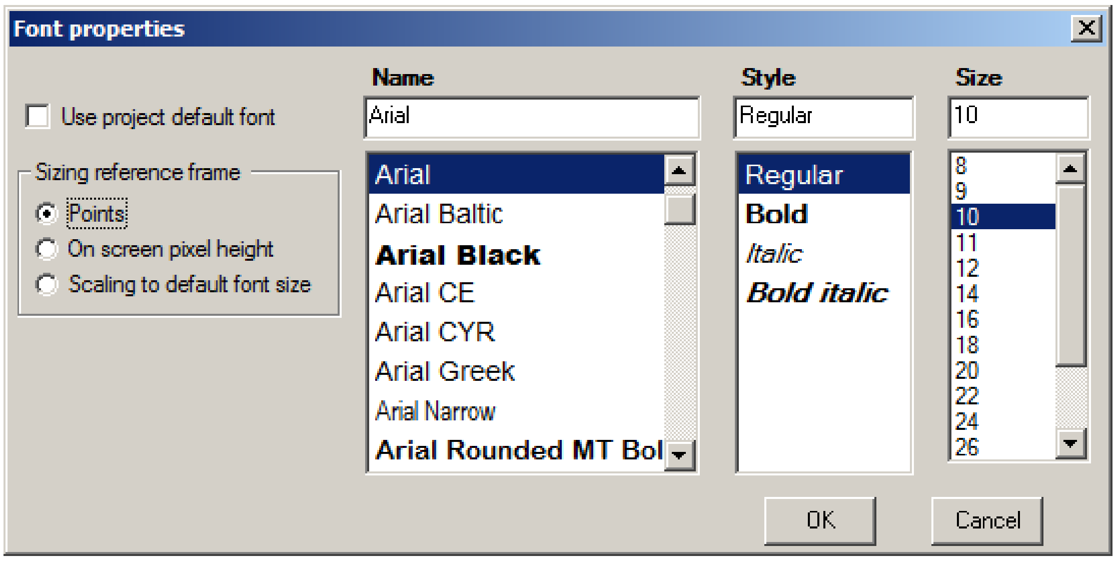
Determines the column number offset for pasted cell associations with respect to the cell column number of the source association in the clipboard. Any positive integer number may be applied to the associated text field, with default zero value. The column number offset of the cell association is incremented for each pasted duplicate by the value specified if the **Incremental** box is checked.

The appearance and operation of the **Paste special** dialog for the Component repository is identical to the dialog described above, however the **Spacing** control items are not shown because they have no relevance to components. When the OK button is pressed Renque components are pasted from the clipboard into the repository.

Components can be assigned to specific properties of server and link objects and to properties of some other component types. Because all properties are copy-pasted through the clipboard, it is therefore possible that the properties of the objects and components copied to the clipboard have assigned component items which do not exist in the current project (for example: if put in the clipboard by another instance of Renque running on the same workstation). If this is the case, such components are recreated and assigned to the corresponding properties of the pasted objects. Similarly, if no embedded workbook exists for pasted spreadsheet cell associations, a new workbook is created, if possible, with worksheets named by the pasted cell associations. If the spreadsheet cell value of a pasted cell associations is empty, the clipboard value is assigned to the empty spreadsheet cell. Reversely, if the target cell of the embedded workbook is not empty, the cell value is applied to the pasted cell association.

9.11 Font selection utility

The font selection utility is used to assign font properties for text display in Renque.



The Name, Style or Size field is left blank if the utility represents multiple objects which have a different value for the corresponding property. For the rest, operation of this utility is fairly similar to the Windows OS standard. The following control items are particular to the application:

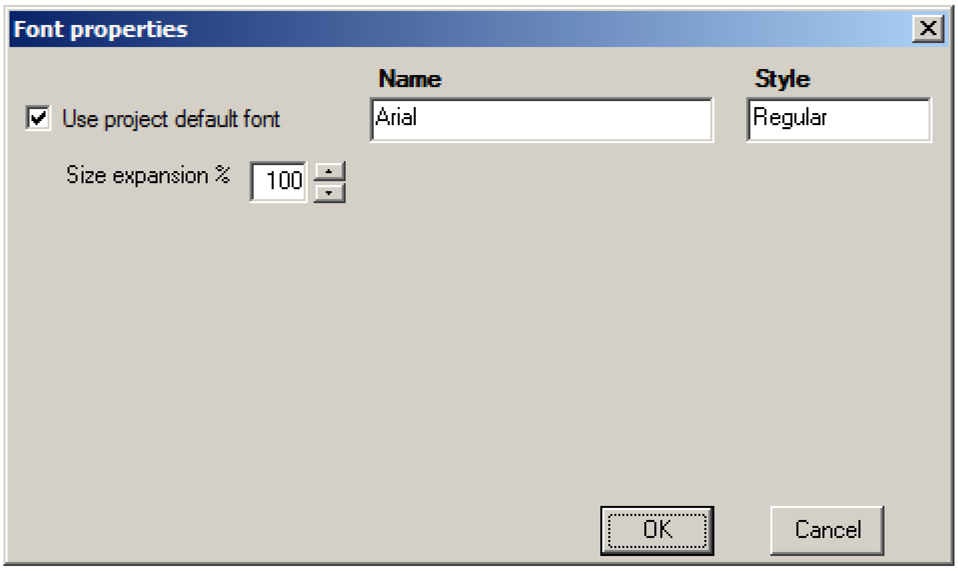
Use project defaults

Forces the application of the Default project font, which is set in the Appearance tab of the preferences utility.

Sizing reference frame

The options contained in this frame control the method by which the font size is expressed. The option **Points** represents the standard Windows font size evaluation method. The Points size is independent of the worksheet zoom factor. Selection of the **On screen pixel height** option changes the font size expression to pixels. Selection of the **Scaling to default font size** option results into expression of the font size as a ratio to the Default project font size. The latter option is not available if the *Use project defaults* option box is checked.

Some text in Renque is sized automatically to fit to the available space in a certain region, such as the text of most graph server elements. If the utility is activated for such fonts, the above mentioned **Size** property is not shown.



Use project default font: ✓

Name	Style
Arial	Regular

Size expansion %: 100

Size expansion %

Sets the relative size for fonts that are sized to fit a certain region. The text field accepts integer numbers in the range 1 - 100, where the value 100 signifies the maximum size to fit the available space.

10 Reference

10.1 The Renque simulation engine

This reference section focuses on the architecture of the Renque simulation engine. After a brief introduction of the mechanism of a Renque simulation, details are discussed in the following topics:

- Operation mechanism of active servers
- Operation mechanism of passive servers
- Operation mechanism of resource servers
- Incitation
- Server status
- Property evaluation
- Entity displacement
- Interruption
- Retraction
- Calendar events

A set of richly annotated project files that illustrate most of the concepts discussed in this section is available for download from the web link:
http://www.renque.com/downloads/EngineRef.zip

10.1.1 Simulation mechanism

The principal constituents of a Renque project are server and link objects. A Renque discrete event simulation basically encompasses the distribution of entities across servers and links. Server objects drive the simulation by inducing the creation, transport, storage and destruction of entities. Link objects connect the servers and accommodate transport of entities between the servers and creation and destruction of entities.

Server types

There are four server types in Renque.

- Operative servers perform entity transformation. An operative server is either Active or Passive. Active servers actively collect entities from upstream-connected links, store entities for a specified time period and dispatch entities along downstream-connected links. Passive servers neither collect nor dispatch entities. Entities arriving at a passive server are stored for an indefinite period of time. They are usually removed as a consequence of collection by a downstream-connected active server. The Toolbox has standard templates for both operative server types. The operative server type property is accessed by scripting through the `IsActive` procedure.
- Resource servers act as provider for shared resources. They allocate resources to active servers, which must compete for the available resources. Shared resources are a common phenomenon in logical systems. Renque models can also be furnished with shared resource functionality by constructions based on links and passive servers. Resource servers present a more expedient way to do this, although with less control options. The Toolbox has a standard resource server template.
- Fusion servers serve as container for other servers and links. Any set of server and link objects can be merged into a Fusion server. Fusions are used to condense a section of a project into a single presentation item. The fusion of objects on the Worksheet does not affect the behavior of the fused objects in a simulation. The fusion server itself has no function other than to represent the fused items on the Worksheet, although fusion servers do have their own statistics recording and animation features. A fusion server can be merged with

other objects on the Worksheet into a higher level fusion server. This process can be repeated to obtain nested fusions at any desired level of nesting.

- Graph servers are used to illustrate the worksheet with clock and simulation data, and with headings, lines and pictures. Simulation data can be presented in different chart types or as text. The simulation clock can also be displayed in various formats. A graph server can be displayed in a separate Graph window. Graph servers have no logical function in the simulation model.

Link types

Links are always connected to a server. The server connected to the upstream side of a link is named the *origin server* of the link; the server connected to the downstream side is the *destination server* of the link. Links connected to the upstream side of a server are referred to as *collecting* links of the server; links connected to the downstream side are *dispatching* links of the server.

There are two link types. One type interconnects servers and the other type is connected to one server only. Single-side connected links are named *creating* links if connected to the upstream side of a server, and *destructing* links if connected to the downstream side of a server. Interconnecting-type links transport entities between servers, creating-type links generate entities on demand by the destination server and destructing-type links delete entities received from the origin server.

All links have a buffer for storage of entities. If an entity arrives on a link with a destination server that is not ready or unable to accept the entity, it is stored in an internal buffer of the link for later removal by the destination server.

Entities

There is only one entity type in Renque. Entities may be distinguished from one another by their Identifier property. The entity Identifier is empty by default. It is assigned by the scripting procedure `Identifier`. The Identifier property is used for attributes in Simulation data display and Statistical analysis (see also: Data storage). When data recording is enabled for an entity attribute by the Attribute script command `Recording`, the entity is assigned an automatically generated unique Identifier value.

Components

Components are user-creatable project elements which are not displayed on the Worksheet. Components are created in the Component repository. There are six component types, which have different purposes in a simulation project:

• Variable	Variable components allow storage of simulation data, either globally, or locally as a property of a server or link object.
• Attribute	Attribute components allow storage of simulation data in entities.
• Distribution	Distribution components generate random numbers in accordance with an specified probability density distribution.
• Schedule	Schedule components present a tool to enable execution of scripts at specific time points in a simulation.
• Picture	Picture files stored on disk can be added as component to the project and used to depict servers or entities on the Worksheet.

Event calendar

The heart of the simulation engine is the event calendar. All simulation actions run through the event calendar. It is a list of events, defined by a procedure type, an event time, a priority value and usually an event object and a specific entity. The event object can be a server or link object, or a schedule component.

A Renque simulation is performed by consecutive execution of calendar events. At the start of a simulation replication a number of initialization events are created in the event calendar. Further addition of calendar events occurs by execution of calendar events only. The simulation terminates when the event calendar is empty.

The events are executed in order of event time. The event time of a newly created calendar event is always greater than or equal to the event time of the currently executed event. Events with identical event time are executed in order of event priority. The Priority property of the server that generates the event is imprinted on the event priority when the event is created. This subjection of the execution order to the Priority property of servers facilitates control over simulation causality of sequentially processed calendar events for things that happen simultaneously in the real world. The execution order of events with both identical event time and priority value is the order of event creation, which is effectively uncontrolled for most practical modeling purposes.

Because of the sequential execution of events the simulation time does not proceed continuously as the real time does, but jumps to the event time of the next calendar event when it is executed.

A discussion of calendar event procedure types is given in section Calendar events.

10.1.2 Operation mechanism of active servers

As discussed in the previous section, active servers collect entities from collecting links, store entities for a specified time period, and dispatch entities to dispatching links. The collection of entities is carried out in three stages:

1. Verification of the availability of entities and resources.
2. Consolidation entities.
3. Transfer of entities to server storage.

These three steps combine into a procedure referred to as the collection procedure of active servers. Although it is possible that all three stages of this collection procedure are carried out consecutively by a single calendar event, execution of the procedure usually halts at one of the three stages because of a missing entity, or because simulation timing demands so. A halted collection procedure will normally be resumed at a later point in the simulation by a routine referred to as incitation. Completion of the collection procedure generally starts a new collection procedure of the server, so that active servers operate in collection cycles.

The collection procedure and other features of the active operation mode are highly user-adaptable by manipulation of the properties of a server and of the links connected to it. The operation of active servers is summarized in the figure contained in this topic and described in detail in the remainder of the text.

Verification

The verification stage of the collection procedure of an active server tests the availability of entities on its collecting links and the availability of resources. An entity is available for collection if the entity meets one of the following requirements:

- The entity is creatable by a Completing creating link.
- The entity is stored in the link buffer.
- The entity is retrievable from a passive origin server of the link.
- The entity is traveling on a link with Passive origin server.

The availability test for collecting links is successful if the number of entities available for collection on the link is equal to or greater than the Required property of the link. For resources, the availability test is successful if the number of available resources at the resource server is equal to or greater than the Allocation requirement property for the server.

The entity availability is first tested for all non-Mandatory collecting links, in top-down connection order. Links that pass the test are placed in the RuleLinks assembly of the server. Subsequently, the Collect Rule selection routine picks a link from the RuleLinks assembly for participation in entity collection. The verification stage continues with testing the entity availability for all Mandatory collecting links, also in top-down connection order. If the server has resource allocation requirements, the procedure ends with verification of the availability of the resources.

The collection procedure will collect entities from the selected non-Mandatory link. Entities will also be collected from all Mandatory links, provided neither the Mandatory link nor the selected non-Mandatory link are Solitary. If the server has only Mandatory collecting links, entity collection takes place only on the non-Solitary collecting links.

The collection procedure is halted if either all non-Mandatory collecting links or any of the Mandatory collecting links fail the availability test. It is also halted if any of the required resources are unavailable, or if a resource server has a higher Priority property value than the collecting server. The latter creates an allocation event for the resource server in the event calendar. A halted verification routine will await incitation by the collecting link or resource server that has caused the halt.

Incitation resumes the verification stage from where it was halted. If the Certified verification property is applied to the server, all successful entity availability tests performed prior to the incitation, are repeated in order to certify that the availability conditions still hold. If a repeated test fails on the selected non-Mandatory link, the verification stage starts over. If it fails on a Mandatory link, verification is halted again. The availability of all resources is retested, regardless of the Certified property value. Any components assigned to object properties are evaluated for the primary availability test only. The evaluation result is stored and used again for retesting.

When verification is complete, the verification stage is concluded with allocation of the required resources, and the collection procedure advances directly to the consolidation stage.

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Before the Collect Rule selection routine takes place, links may be removed from the RuleLinks assembly by rule assembly scripting procedures in the Select collect incident of the server. The selected non-Mandatory link may be referenced by the scripting function `SelectedLink` for the duration of the collection procedure.

Consolidation

The consolidation stage comprises retrieval of entities to the link buffers of collecting links for which participation in entity collection has been resolved by the verification stage. The number of entities collected on a link is determined by the Batch and Excess properties of the link.

The retrieval mechanism depends on the nature of the link connection:

- Entities to be consolidated on creating links are created by the link, provided the link is Completing.

- Entities to be consolidated on links with a passive origin server are removed from the server. However, if the Suspending property is applied to the link, consolidation is skipped and retrieval is performed by transfer in the next stage of the collection procedure. If also the Claiming property is applied to the link, the collected entities will not be available to other active servers while stored in the passive server.
- Links with an active origin server are ignored in the consolidation stage because the entities available for collection are already stored in the link buffer.

The way entities are stored in the link buffer by consolidation depends on the link properties Upstream buffering and Uniting. By default, the link buffer is located at the downstream side of the link. The consolidated entities are sent traveling to the link buffer and storage into the buffer occurs upon arrival at the buffering end of the link. In contrast, if the Upstream buffering property is applied the buffer is located at the upstream side of the link and consolidated entities are stored into the buffer immediately. If the collecting link is Uniting, all consolidated entities are merged into the first entity stored in the link buffer, which is referred to as the Unite entity. This entity continues to be the unite entity until all consolidated entities have been united.

Entities are ready to be transferred to the server if they are present in the buffer of a collecting link or in the origin server of a Suspending collecting link. The collection procedure is halted in the consolidation stage if one or more collected entities are not ready for transfer. If the Premature property is applied to the server, before being halted in the consolidation stage, the transfer routine is executed provisionally for those collected entities that are ready for transfer. The collection procedure enters the transfer stage conclusively if all entities to be collected are ready for transfer.

Transfer

The transfer stage of the collection procedure of active servers comprises transfer of entities to the server for storage. The transfer mechanism depends on the location of the entity to be transferred, which is governed by the Upstream buffering and Suspending properties of the link. If neither of these properties are applied the entity is simply removed from the buffer and stored in the server. If only the Upstream buffering option is applied the entity is removed from the buffer and transferred to the server by travel on the link. If the Suspending option is applied the entity is first removed from the origin server of the link and stored in the link buffer (Upstream) or sent to the link buffer by travel (not Upstream). Upon storage in the buffer the entity is transferred by the same routine as without application of the Suspending property.

Transfer is performed for all entities collected, for each collecting link consecutively, in top-down order. By default, the collection procedure is halted when it doesn't succeed in immediate storage of an entity in the server. Failure to do so can have three causes, which are:

- Transfer of an entity is prohibited by the server's Capacity property.
- An entity to be transferred is not present (Premature property applied).
- One or more entities have been transferred to the server by travel on a collecting link (Upstream or Suspending property applied, or both).

Application of the Disordered property overrides the latter two restrictions, which results into transfer of all entities that are ready for transfer, until the Capacity limit is reached.

Transferred entities are stored in an active server for a time period specified by the Timing property of the server. By default, all entities stored by the operative collection procedure are assigned a uniform storage time. However, if the Discrete timing property is applied, the Timing property is evaluated for each stored entity individually. If the Uniting property is applied to an active server, the collected entities are merged into a single entity, referred to as Unite entity. The Unite entity is the first entity stored in the server by the operative collection procedure. This entity continues to be the unite entity until all collected entities have been united.

The transfer stage is complete when all collected entities have been stored in the server. By default, completion of the transfer stage also completes the operative collection procedure, and starts a new collection procedure for the server. If the Integrated dispatch property is applied to the server, the operative collection procedure is not completed until all collected entities have been dispatched by the server.

Dispatch

The dispatch routine of an active server removes an entity from storage in the server and sends it to a selected dispatching link. This entity is referred to as dispatch entity. The dispatch routine may duplicate the dispatch entity and also send duplicates to dispatching links of the server.

A link is said to be selectable in the dispatch routine if its destination server is not both Passive and Disabled. Similar to the verification stage for collecting links, the dispatch routine tests if the non-Escort dispatching links are selectable, in top-down connection order. Links that pass the test are placed in the RuleLinks assembly of the server, after which the Dispatch Rule selection routine picks a link from the assembly to send the dispatch entity to. Copies of the dispatch entity are sent to Escort links, provided neither the Escort link involved nor the selected non-Escort link are Independent.

A Discard incident occurs if no dispatching link can be selected for the dispatch entity, which happens if either the server has only Escort dispatching links or all non-Escort dispatching links fail the selection test. In case of the latter the dispatch routine is cancelled.

The Departures property of a dispatching link determines the number of entities dispatched by the link. If the Departures property of the selected non-Escort link has a value exceeding unity, copies of the dispatch entity are sent along with it, whereas a zero Departures number causes a Discard incident. If a dispatching link is Upstream buffering and its destination server is Active or Disabled, a dispatched entity is stored in the link buffer. Otherwise, the entity is sent to the destination server of the link by travel.

Before the Dispatch Rule selection routine takes place, links may be removed from the RuleLinks assembly by rule assembly scripting procedures in the Select dispatch incident of the server. During the dispatch procedure the selected non-Escort link may be referenced by the scripting function `SelectedLink`.

By default, a new collection procedure starts right after conclusion of the above-mentioned transfer stage. If the Integrated dispatch property is applied to the server, a new collection procedure is started when all collected entities have been dispatched from the server.

Entity bonding

The Bonding consolidation property protects active server operation against disturbances resulting from entity displacement, through a mechanism called entity bonding.

If the Bonding property is applied to an active server, entities are bonded by the server when consolidated in the buffer of a collecting link or claimed in a passive server. The bond is not released until the entity leaves the bonding server or collection of the entity is cancelled.

Servers do not bond specific entities: If the link or server host of a bonded entity has other residents that are not claimed or bonded by a server, the bond of a displaced entity shifts to another resident and entity displacement will have no effect on the bonding server. The entity scripting command `Bonded` is used to determine if an entity is bonded.

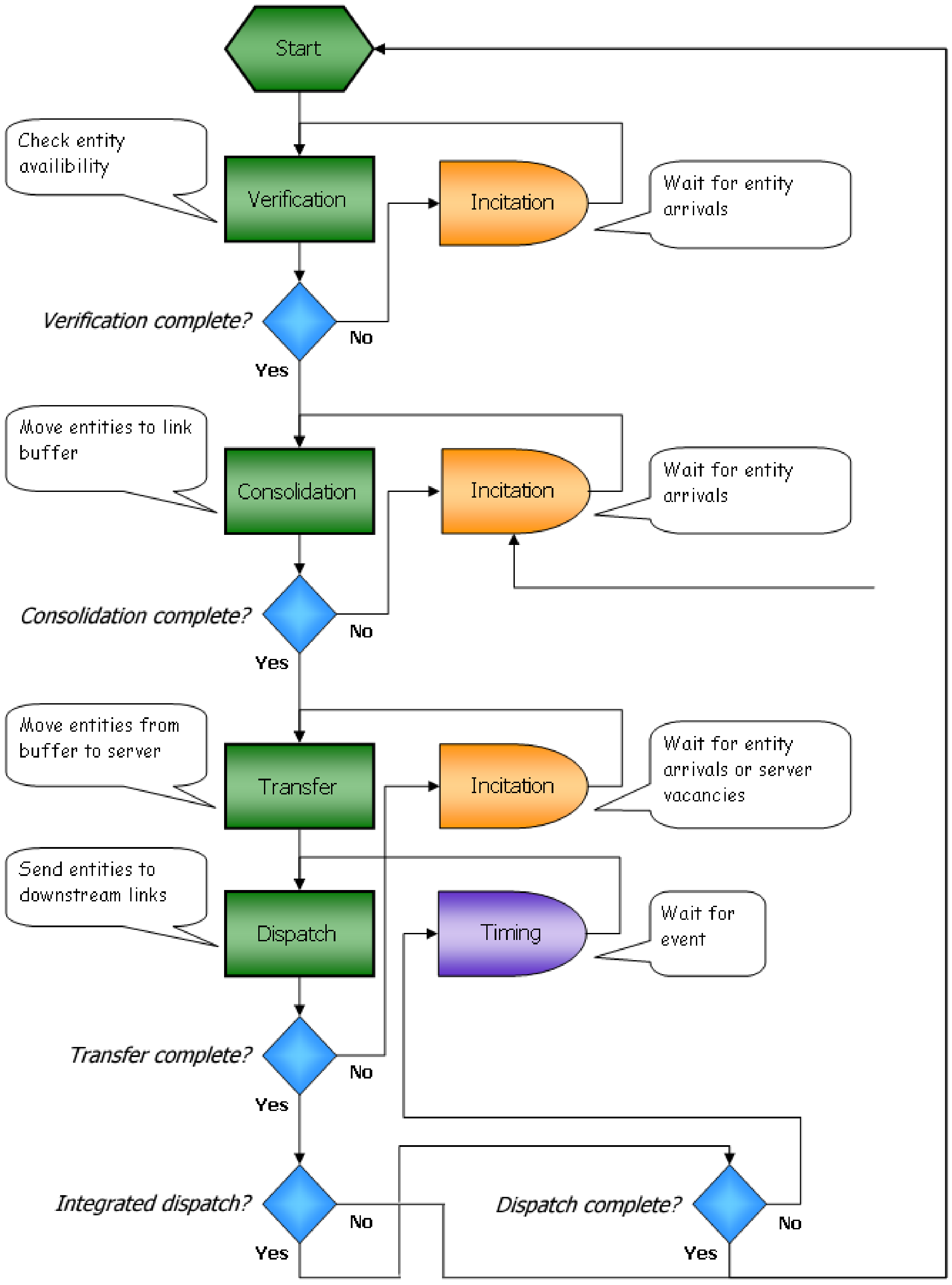

Figure. *Basic flowchart of the collection procedure of non-Premature active servers.*

10.1.3 Operation mechanism of passive servers

Arrival

Entities can only be stored in passive servers through a collecting link of the server. Entities supplied to a collecting link of the server are sent traveling to the server and will be stored in the server when arriving at the downstream end of the link.

Passive servers that are Disabled do not accept entities for storing. If a server has the Disabled status, the entities supplied to a collecting link of the server are stored in the link buffer instead. When a disabled passive server is enabled, entities stored in the buffer of collecting links of the server are either sent to the server (Upstream links) or immediately stored in the server (non-Upstream links).

It is possible for an entity to arrive at the downstream side of an Upstream buffering link connected to a Disabled passive server, if either or both of these properties were changed during travel of the entity. In that case neither the link nor the server can accommodate the arriving entity, and the entity is deleted or retracted if it has a non-*Void* retraction status.

An entity stored in a passive server is assigned a maximum residence time, determined by the Timing property of the server. If the Timing property is not *Void*, a calendar event is created that generates an Expiration incident for the entity. The Discrete timing property has no function for passive servers: The Timing property is evaluated for each individual entity stored.

Storage of an entity in a passive server generates an event for incitation of active servers connected to a dispatching link of the passive server.

Retrieval

Active servers retrieve entities from storage in passive servers by consolidation. If a passive server has more than one resident, the Passive rule of the host server governs which of the stored entities is consolidated. There are three possible values for the Passive rule. The default value *FIFO* (First-In-First-Out) results into selection of the first stored entity. The value *LIFO* (Last-In-First-Out) causes selection of the last stored entity. The value *Random* results into random selection of a resident entity.

The Passive rule can also be assigned a variable or distribution component. In that case the retrieved entity is selected by evaluation of the assigned component. If this property evaluation fails, the above-mentioned fixed rule value is applied instead.

The resident selection routine is configurable through incident scripting on the RuleResidents assembly. Once an entity has been selected for retrieval, it may be referenced by the scripting function `SelectedResident` until it leaves the passive server.

10.1.4 Operation mechanism of resource servers

Resource servers are stations for allocation and deallocation of resources. The properties of resource servers are specified on the Resource tab of the Object properties console. The set of active servers that demand resources from a resource server form a sequence, which is referred to as the Allocation preference order of the resource server. The number of resources to be allocated to an active server is referred to as the Allocation requirement.

Active servers require allocation of the resources to complete the verification stage of the collection procedure. Resources are allocated as final step in the verification stage. Deallocation of the resources back to the resource server takes place when the collection procedure is completed, which is governed by Integrated dispatch property of the server. A resource server allocates resources to active servers by incitation.

The total number of resources available for allocation by a resource server is equal to the Capacity property of the server. If the resource server has the *Void* capacity, there is no limit to the resource availability. If the capacity value changes during a simulation to a value smaller than the current number of available resources (i.e. the previous capacity minus the number of allocated resources), the current availability is set to zero, and remains zero until resource de-allocations render the number of allocated resources equal to the capacity.

Unlike entities, resources cannot be referenced as individual objects. Therefore resources are not animated. The resource server does have the capability for resource availability statistics recording. The recorded statistical properties are the same as for operative servers, with the exception that the Residence property is undefined.

The allocation requirements are accessible by scripting through the `Allocation` scripting procedure. The current number of resources allocated to an active server is accessible by the `AllocationLoad` procedure. Deallocation of resources to the resource server can be forced by the `Retract` scripting procedure. A retract call on a resource server results into interruption of all active servers that have allocated resources of the resource server.

10.1.5 Incitation

Incitation resumes a halted collection procedure of active servers. Incitation is performed whenever the condition that caused the collection procedure to be halted is eliminated. Resumption of the collection procedure takes place from the stage at which it was halted. The situations that may cause incitation are:

- An entity is stored in a link buffer,
- A vacancy is created on the server by dispatch, entity displacement or a capacity increase,
- A transferred entity arrives at the server by travel on an Upstream buffering link,
- An entity is stored in a passive server.
- A resource becomes available at a resource server.

The latter two may serve incitation of different active servers.

Incitation by passive servers

A passive server can have more than one dispatching link. The passive server uses a routine similar to the dispatch routine of active servers to incite downstream connected active servers in a controlled manner. The routine is carried out by event to allow multiple entities to be stored in the passive server before the incitation is carried out.

The passive dispatch event tests if the non-Escort dispatching links are selectable, in top-down connection order. A link is selectable if the server has sufficient residents to incite the collection procedure of its active destination server. Links that pass the test are placed in the RuleLinks assembly of the server, after which the Dispatch Rule selection routine picks a link from the assembly for incitation. Incitation is also performed on all Escort links, provided neither the selected non-Escort link, if any, nor the Escort link involved are Independent.

The passive dispatch routine is cancelled if all non-Escort dispatching links fail the selection test. In contrast with the dispatch routine of active servers, the passive dispatch routine continues selecting additional non-Escort links, for as long as the passive server has resident entities that can be employed to incite the destination server of remaining non-Escort links. Because servers can be incited only once in a single event, a component assigned to the Dispatch Rule is evaluated only for the first selection.

Before the initial Dispatch Rule selection takes place in the passive dispatch routine, links may be removed from the RuleLinks assembly by rule assembly scripting procedures in the Select dispatch incident of the server. During the incitation procedure the selected non-Escort link may be referenced by the scripting function `SelectedLink`.

Incitation of a collection procedure halted in the verification stage does not result into evaluation of a component assigned to the link properties Batch and Required. Such components are evaluated only for the initial execution collection procedure.

Incitation by resource servers
A resource server will normally have demand for its resources by two or more active servers When the number of available resources of the resource server increases, there may be multiple active servers for which verification was halted because of prior failure to receive allocate resources from the resource server. The collection procedure of such servers is incited by the resource server in the order determined by the Allocation rule of the resource server. The incitation routine continues, for as long as the resource server has available resources and incitable active servers. The incitation routine is carried out by the Allocation Calendar event. This event is created by deallocation of resources to the resource server or a capacity increase of the resource server.

10.1.6 Server status

A server can have three possible status. These are Idle/Empty, Occupied and Disabled. For passive servers the nature of the server status is evident: Idle/Empty when no entities are stored, Occupied when at least one entity is stored, and Disabled when the Disabled property has been applied. For active servers the status accounting method depends on the Idle when empty property. By default, the server assumes the Occupied status when the verification stage of the collection procedure is complete and doesn’t re-enter the Idle/ status until the last resident has left the server and the next collection procedure has been halted in the verification stage. On the other hand, if the Idle when empty property is applied the status accounting method for active servers is the same as for passive servers.

The initial status of all servers is set at the start of a simulation replication after entities created by Initializing links have been stored in their destination servers.

10.1.7 Property evaluation

The component types attribute, variable and distribution are evaluating components. They differ from other component types in possessing a current value, which is returned by the `Eval` function.

In Renque, some object properties can be assigned an evaluating component, either through the user interface or by scripting. Components can be assigned to all numerical properties of servers and links, to the three Rule properties of servers, and to the distribution parameter properties of distribution components

In general, the current value of the assigned component is evaluated and applied when the object property comes into effect in the simulation. The server properties Capacity, Priority and Shielding form an exception. For these properties, the evaluation is done at the start of a simulation replication and when the Disabled status of a server changes to *False* (i.e. the server is enabled). A component assigned to a parameter property of a distribution component is evaluated only when the distribution component itself is evaluated.

The component evaluation should generally produce a numeric value that is suitable for application to the property. The significance of component evaluation for the rule properties is as follows: For the Passive rule, the evaluation result signifies the entity storage location number, counting from the first entity stored. For the Collect rule and Dispatch rule of servers, a numerical evaluation result signifies the link connection number, counting in top-down order. If the evaluation returns a link object, the evaluation result signifies the link object itself.
The evaluation of a component assigned to an object property fails if the evaluation result is incompatible with the object property. Component evaluation always fails for distribution components with an invalid set of distribution parameters. An evaluation failure creates a warning in the Runtime error viewer without causing an actual runtime error: An evaluation failure for the Rule properties of servers results into application of the Rule value of the *Reset* status. For other server and link properties, the previously applied value is reapplied or, if none, the default value. For the parameter properties of a distribution component, a failed component evaluation renders the distribution parameter set invalid.

10.1.8 Entity displacement

Entities are normally removed from servers and link buffers by collection or dispatch by an active server. The phrase used for entity removal by other causes is entity displacement. Entities can be displaced from link and server objects and are usually sent to a specified recipient link. Entities displaced to a link object are accommodated by the recipient link in the same manner as entities created on a link.

Entity displacement incidents

There are four entity displacement incident types in Renque.

Overflow incident

An overflow incident is caused by a Capacity deficiency of a server. The arrival of an entity at a server of which the Capacity property prohibits storage of the entity causes an overflow incident. An overflow incident also occurs when the server is assigned a Capacity value smaller than the number of residents, provided the Preemptive capacity property has been applied. In that case, as many entities as required to restore compliance with the new Capacity value are removed from the server in last-in-first-out order. The designated recipient link for overflow incidents is the Overflow recipient.

Expiration incident

An expiration incident arises from expiration of the maximum residence time assigned to entities stored in a passive server, as determined by the Timing property of the server. The designated recipient link for expiration incidents is the Expiration recipient.

Discard incident
A Discard incident occurs for both passive and active servers when an entity is removed from the server by interruption. For active servers a Discard incident also occurs during dispatch, in case the dispatch entity cannot be sent to a dispatching link. The designated recipient link for Discard incidents is the Discard recipient.
Relocation incident
A relocation incident is effected by the scripting statements `Retract` and `Extract`. These commands extract an entity from a server or a link buffer and send it to a link specified by the script command. The recipient link for relocation incidents may be any link object in the project.

Undirected displacement
If no recipient is specified for a displacement incident, the fate of the displaced entity depends on its bonding and retraction status. Entities displaced from link buffers and active servers without specified recipient are destructed, unless the entity has a non-*void* retraction status, in which case retraction is applied. The same applies to entities displaced from passive servers, with the exception that bonded entities are sent to the top-most dispatching link that has a destination server bonding the displaced entity.

Bonded displacement
If a displaced entity is bonded, the bonding server is interrupted. For bonded entities displaced from passive servers, interruption is omitted if the destination server of the recipient link is bonding the entity. Otherwise, the destination server of the top-most dispatching link that has a destination server that bonds the displaced entity is interrupted. If an entity is displaced from an Bonding active server by an overflow incident, the interruption takes place after removal of all entities exceeding the capacity limit.

10.1.9 Interruption

Interruption of a server results into instantaneous removal of all entities stored in the server. The removal of an entity by interruption causes a Discard incident. A passive server continues normal operation after removal of the residents. The response of an active server to an interruption depends on the Abortive interruption property of the server. If the Abortive property is applied, interruption aborts the collection procedure by cancellation of all pending verification, consolidation and transfer operations. The travel of transferred entities on Upstream buffering links is terminated, which causes a Discard incident. A new collection procedure is started directly after the abortive interruption. Without application of the Abortive property, the server assumes the interrupted status, and continues normal operation with the distinction that transferred entities are not stored in the server. Instead, their arrival is treated as Discard incident. The interrupted status ends when the collection procedure is complete, and a new collection procedure is started.

A server can be interrupted by the `Interrupt` scripting statement. The Interrupt statement has an optional argument *Level*, with default value zero. The interruption command is ineffective if the *Level* argument value is smaller than the Shielding value of the server.

A server is also interrupted if the Timing property of a server changes under application of the Interruptive timing property and if an entity bonded by the server is displaced. In addition, a modification of a server or link property that disturbs the operative collection procedure of an active server will cause a forced Abortive interruption. The properties imposing such interruptions are:

- ***Server properties***: IsActive; Disabled (if set *True*); Uniting; Integrated; Premature and Disordered.
- ***Link properties*: **Completing, Mandatory, Solitary, Required (if the operative collection procedure was halted in the verification stage); Suspending; Claiming; Uniting and Upstream.

If one such interruption imposing property change is made while a simulation has been paused, the interruption is implemented when the simulation run is continued.

10.1.10 Retraction

Retraction is effected by the `Retract` scripting statement and entails forced return of entities to the link by which they were created. A retract scripting statement call on a link will attempt to return all entities that were created by that link under application of the Tracking property.

The effect of the `Retract` statement call on an entity subjected to the call depends on the location of the entity and on the value of a *Level* argument passed with the script statement. The statement call can be canceled, deferred or applied. A canceled statement call has no effect on the entity. A deferred call increases the retraction status of the entity to the value of the *Level* argument. If the call is applied, the resulting Relocation incident instantaneously moves the entity from its current location to the retracting link.

The `Retract` call is deferred if an entity subjected to retraction is not stored in a host object. If the entity does have a host object, the retraction result depends on the *Level* argument of the `Retract` call and the Shielding property of the host object. The call is applied if the *Level* argument value is equal to or greater than the Shielding value of the host. If the *Level* argument is smaller than the Shielding value, the `Retract` call is canceled if the host is Revoking, and deferred if not Revoking. If the host is a link, the Shielding and Revoking properties of the destination server are applied to determine the outcome of the statement call .

An entity with a non-*Void* retraction status continues its normal path through the project, with the following exceptions:

- Retraction is reattempted each time the entity is stored in a server: Retraction is applied if the retraction status of the entity is equal to or greater than the Shielding value of the server. Otherwise, if the server is Revoking, the retraction status is reset to *Void*.
- The retraction status is reset to *Void* unconditionally when the entity is stored in the destination server of its creating link.
- Reaction is applied unconditionally when the entity is to be deleted by a method other than through a deleting link.

The retraction status of an entity is accessible through scripting by the attribute function `Retracted`.

10.1.11 Calendar events

All simulation actions result from execution of calendar events. A simulation replication starts by a **Start simulation** event, which creates the events required to initialize all simulation elements. The event creates **Initialization** events for active servers and for passive servers that have one or more Initializing collecting links. Furthermore, for schedule components a **Scheduling** event is created that will generate further Scheduling events to execute schedule items at event times determined by the timing properties of the schedule component. The **Start**

simulation event may also create an **Activate timetable** event, which controls synchronization of the Calendar-based simulation clock, if applied.

In general, a single calendar event will perform as many tasks as the project composition allows. Simulation actions succeeding the arrival of an entity at the downstream end of a link are always performed by event, as are actions taking place at a simulation time later than the event time of the current event, of course.

For active servers, the first collection procedure is started by an **Initialization** event created by the **Start simulation** event. Subsequent collection procedures are started directly from an event operating on the server, without creation of a new calendar event.

In the collection procedure of active servers, depending on the Upstream buffering property, entities may require travel on collecting links. If travel is required for a collected entity, the operative collection procedure is halted and an event is created to incite the server when the entity arrives at the other side on the link. Thus, consolidation of entities on non-Upstream collecting links and transfer of entities on Upstream links are performed by **Arrival** and **Transfer** events respectively. The **Completement** event is used to process collected entities arriving at a passive server on a Completing creating-type link.

Dispatch of entities with zero storage time is performed directly in the transfer stage of the collection procedure of active servers, whereas a **Dispatch** event is created for entities that are stored for a certain time period. Depending on the properties of the dispatching link and its destination server, the dispatch entity is either stored in the link buffer or sent traveling to the destination server. For the latter occasion an **Arrival** event is created, which will process the entity upon arrival. Both occasions may incite an active destination server of the dispatching link.

The event types **Incitation** and **Expiration** are used for passive servers. As the names suggest, the **Expiration** event generates an Expiration incident and the **Incitation** event incites downstream connected active servers.

The event types indicated by the phrase **Postponed** represent events performing a duty that the simulation was unable to carry out in a prior event. The event object of an event that processes an entity cannot be interrupted, and entity displacement from the event object is not allowed during execution of the event. Therefore, scripting commands that require interruption of the event object, or displacement of an entity from the event object, are skipped in the event execution and performed by a separate event.

Finally, the **Modify** event is created when the user resumes a paused simulation after making changes to the project that affect the simulation in progress. The event implements the changes made to the project by standard routines such as interruption and incitation of servers.

The Priority property value of server objects and schedule components is imprinted on the event priority of events generated by these objects. This applies to the Arrival, Transfer, Completement, Dispatch, Expiration, Incitation, Initialization and Scheduling event types. The Start simulation, Modify, postponing and timetable events are all created with so-called System priority, which means that these events are given the highest priority value. Events created by execution of a script are assigned the priority of the current event.

The table below lists all Renque calendar event types, as displayed in the Event viewer, with a concise description of their functions.

Event type	Description
Start simulation	Starts a simulation replication. The event creates other events to initialize objects and components of the simulation project.
Arrival	General entity arrival event, associated with the arrival of a traveling entity at the downstream side of a link. The function of the event depends on the nature and condition of the destination server of the link.
Transfer	Executed when a transferred entity arrives at the downstream side of a link. The event stores the entity in the active destination server of the link.
Completement	Executed when a consolidated entity arrives at the downstream side of a completing link. The event stores the entity in the passive destination server and subsequently sends the entity to the link connecting the active server that created the entity.
Dispatch	Dispatches an entity from an active server.
Expiration	Generates an expiration incident.
Incitation	Created when an entity is stored in a passive server. The event attempts to incite downstream connected active servers.
Allocation	Created when a resource becomes available at a resource server. The event attempts to incite active servers, that have a resource allocation requirement for the resource server.
Initialization	Initializes a server. Implements the function of initializing collecting links connected to a server, or starts a new collection routine for an active server.
Scheduling	Executes a schedule component line and creates a Scheduling event for the next schedule line.
Postponed interruption	Interrupts a server when omitted in a prior event.
Postponed retraction	Retracts an entity from a server or a link when omitted in a prior event
Postponed assignment	Assigns a property to a link or server object when omitted in a prior event.
Postponed displacement	Performs an Extract script statement when omitted in a prior event.
Activate timetable	Activates an exception timetable of the calendar-based simulation clock.
Deactivate timetable	Deactivates an exception timetable of the calendar-based simulation clock.
Modify	Implements changes made in the *Paused* status into the project.

10.2 Random number generation

Simulation results may possess stochastic properties as a result of the application of distribution components in the project. These components make use of a built-in pseudo random number generator, which is based on the widely used Lehmer algorithm[1]. The random number generator produces a sequence of unique floating point numbers $0 < x_i < 1$, starting from a specified seed value. Because the seed value is hard-coded into Renque, the random number sequences are reproducible across different systems.

[1] S. K. Park and K. W. Miller (1988), Communications of the ACM, **31**(10): 1192–1201

10.3 Formatting by placeholder strings

This section provides a complete list of placeholder strings recognized by Renque. Placeholder strings consist of one or more characters that will be replaced by a literal string, in a format determined by the placeholder string. The placeholder strings are organized in tables by function, which provide a brief description of the placeholder purpose.

Named date formats for the calendar-based clock time

General Date	Display a date and/or time. For real numbers, display a date and time, for example, 4/3/93 05:34 PM. If there is no fractional part, display only a date, for example, 4/3/93. If there is no integer part, display time only, for example, 05:34 PM. Date display is determined by your system settings.
Long Date	Display a date according to your system's long date format.
Medium Date	Display a date using the medium date format.
Short Date	Display a date using your system's short date format.

Date format characters for the calendar-based clock time

/	Date separator. The date separator separates the day, month, and year when date values are formatted. The actual character used as the date separator in formatted output is determined by your system settings.
c	Display the date as `ddddd` and display the time as `ttttt`, in that order. Display only date information if there is no fractional part to the date serial number; display only time information if there is no integer portion.
ddddd	Display the date as a complete date (including day, month, and year), formatted according to your system's short date format setting. The default short date format is `m/d/yy`.
dddddd	Display a date serial number as a complete date (including day, month, and year) formatted according to the long date setting recognized by your system. The default long date format is *mmmm dd, yyyy*.
ww	Display the week of the year as a number (1 – 54).
m	Display the month as a number without a leading zero (1 – 12). If *m* immediately follows h or hh, the minute rather than the month is displayed.
mm	Display the month as a number with a leading zero (01 – 12). If *mm* immediately follows h or hh, the minute rather than the month is displayed.
mmm	Display the month as an abbreviation (Jan – Dec).

mmmm	Display the month as a full month name (January – December).
q	Display the quarter of the year as a number (1 – 4).
y	Display the day of the year as a number (1 – 366).
yy	Display the year as a 2-digit number (00 – 99).
yyyy	Display the year as a 4-digit number (100 – 9999).
d	Display the day as a number without a leading zero (1 – 31).
dd	Display the day as a number with a leading zero (01 – 31).

Named time formats for the unit-based clock time

Long Time	Display a time using your system's long time format; includes hours, minutes, seconds.
Medium Time	Display time in 12-hour format using hours and minutes and the AM/PM designator.
Short Time	Display a time using the 24-hour format, for example, 17:45.

Time format characters for the unit-based clock time

Character	***Description***
:	Time separator. The actual character used as the time separator in formatted output is determined by your system settings.
ddd	Display the day as an abbreviation (Sun – Sat).
dddd	Display the day as a full name (Sunday – Saturday).
w	Display the day of the week as a number (1 for Sunday through 7 for Saturday).
h	Display the hour as a number without leading zeros (0 – 23).
Hh	Display the hour as a number with leading zeros (00 – 23).
N, :m	Display the minute as a number without leading zeros (0 – 59).
Nn, :mm	Display the minute as a number with leading zeros (00 – 59).
S	Display the second as a number without leading zeros (0 – 59).
Ss	Display the second as a number with leading zeros (00 – 59).
ttttt	Display a time as a complete time (including hour, minute, and second), formatted using the time separator defined by the time format recognized by your system. A leading zero is displayed if the leading zero option is selected and the time is before 10:00 A.M. or P.M.

AM/PM	Use the 12-hour clock and display an uppercase AM with any hour before noon; display an uppercase PM with any hour between noon and 11:59 P.M.
am/pm	Use the 12-hour clock and display a lowercase AM with any hour before noon; display a lowercase PM with any hour between noon and 11:59 P.M.
A/P	Use the 12-hour clock and display an uppercase A with any hour before noon; display an uppercase P with any hour between noon and 11:59 P.M.
a/p	Use the 12-hour clock and display a lowercase A with any hour before noon; display a lowercase P with any hour between noon and 11:59 P.M.
AMPM	Use the 12-hour clock and display the AM string literal as defined by your system with any hour before noon; display the PM string literal as defined by your system with any hour between noon and 11:59 P.M. AMPM can be either uppercase or lowercase, but the case of the string displayed matches the string as defined by your system settings. The default format is AM/PM.

Count formats for the unit-based clock time

Weeks	Display the number of completed 7-day intervals in the simulation clock.
WeeksCalendar	Display the number of First weekday occurrences in the simulation clock, excluding the simulation start day.
Days	Display the number of completed days in the simulation clock.
Hours	Display the number of completed hours in the simulation clock.

Count formats for the calendar-based clock time

Years	Display the number of calendar year changes in the simulation clock.
Months	Display the number of calendar month changes in the simulation clock.

Other time formats

Character	***Description***
simtime, st	Display the simulation time with no formatting.
T	Display the clock time in the default format.
.	Decimal separator. The actual character used as the decimal separator in formatted output is determined by your system settings.

0	Digit placeholder for the simulation time. Display a digit or a zero. If the expression has a digit in the position where the 0 appears in the format string, display it; otherwise, display a zero in that position. If the number has fewer digits than there are zeros (on either side of the decimal) in the format expression, display leading or trailing zeros. If the number has more digits to the right of the decimal separator than there are zeros to the right of the decimal separator in the format expression, round the number to as many decimal places as there are zeros. If the number has more digits to the left of the decimal separator than there are zeros to the left of the decimal separator in the format expression, display the extra digits without modification.
#	Digit placeholder the simulation time. Display a digit or nothing. If the expression has a digit in the position where the # appears in the format string, display it; otherwise, display nothing in that position. This symbol works like the 0 digit placeholder, except that leading and trailing zeros aren't displayed if the number has the same or fewer digits than there are # characters on either side of the decimal separator in the format expression.
(.)	Decimal placeholder the simulation time. The decimal placeholder determines how many digits are displayed to the left and right of the decimal separator. If the format expression contains only number signs to the left of this symbol, numbers smaller than 1 begin with a decimal separator. To display a leading zero displayed with fractional numbers, use 0 as the first digit placeholder to the left of the decimal separator. The actual character used as a decimal placeholder in the formatted output depends on the Number Format recognized by your system.
(,)	Thousand separator the simulation time. The thousand separator separates thousands from hundreds within a number that has four or more places to the left of the decimal separator. Standard use of the thousand separator is specified if the format contains a thousand separator surrounded by digit placeholders (*0* or #). Two adjacent thousand separators or a thousand separator immediately to the left of the decimal separator (whether or not a decimal is specified) means "scale the number by dividing it by 1000, rounding as needed." For example, you can use the format string "##0,," to represent 100 million as 100. Numbers smaller than 1 million are displayed as 0. Two adjacent thousand separators in any position other than immediately to the left of the decimal separator are treated simply as specifying the use of a thousand separator. The actual character used as the thousand separator in the formatted output depends on the Number Format recognized by your system.
(E- E+ e- e+)	Scientific format the simulation time. If the format expression contains at least one digit placeholder (*0* or #) to the right and left of E-, E+, e-, or e+, the number is displayed in scientific format and E or e is inserted between the number and its exponent. The number of digit placeholders to the right determines the number of digits in the exponent. Use E- or e- to place a minus sign next to negative exponents. Use E+ or e+ to place a minus sign next to negative exponents and a plus sign next to positive exponents.

literal format characters

^	Insert a tab stop.
(\)	Display the next character in the format string. To display a character that has special meaning as a literal character, precede it with a backslash (\). The backslash itself isn't displayed. Using a backslash is the same as enclosing the next character in double quotation marks. To display a backslash, use two backslashes (\\).

10.4 Renque scripting procedure name list

Abortive	S*
Allocation	S
AllocationLoad	S
AllocationReset	S
AllocationRule	S
AllocationRuleReset	S
Animated	Glb
AnimationSpeed	Glb
Assess	Asm
AttributeEntity	S, Da
Batch	L
BatchReset	L
Bonded	Ent
Bonding	S
CalendarDate	Clk
Capacity	S
CapacityReset	S
Caption	S
CellValue	Glb
Certified	S
Claiming	L
Clock	Glb
ClockTime	Clk,Glb
CollectRule	S
CollectRuleReset	S
CollectWeight	L
CollectWeightReset	L
ColumnIndex	Sc
Completing	L
Count	Asm
CycleReset	Asm
DateDay	Clk
DateMonth	Clk
DateQuarter	Clk
DateWeek	Clk
DateYear	Clk
Days	Clk
Departure	Ent
Departures	L
DeparturesReset	L
Destination	L
Dimension	S
Disabled	S
Discard	L
Discrete	S
Disordered	S
DispatchRule	S
DispatchRuleReset	S
DispatchWeight	L
DispatchWeightReset	L
Enabled	S
EntityCreate	L
Entry	Ent
Escort	L
Eval	D,V,A
Excess	L
ExcessReset	L
Exclude	Asm
Expiration	L
Extract	Ent
FirstWeekDay	Clk
Freeze	Glb
HasAttributeEntity	S, Da
HasItem	Asm
Host	Ent
Hours	Clk
Icon	Ent
Identifier	Ent
Idle	S,F
Independent	L
Index	S,F,Cc
Integrated	S
Initializing	L
Interrupt	S
InterruptAllowed	S
Interrupted	S
Interruptive	S
IsActive	S
IsDisabled	S
IsIdle	S
IsOccupied	S
IsUniteEntity	Ent
IsVoid	Glb
Item	Asm
LinkFrom	S
Links	S
LinksIndex	L
LinksCount	S
LinksEval	S
LinkTo	S
Mandatory	L
Member	Asm
Minutes	Clk
Months	Clk
Name	S,F,L,Cc
Occupied	S,F
Origin	L
LinksIndex	L
Overflow	L
Parameters	D
ParametersReset	D
ParametersSet	D
PassiveRule	S
PassiveRuleReset	S
Pause	Glb
Picture	S
PictureReset	S
Population	S,F,L
PositionShift	S
Preemptive	S
Premature	S
Priority	S
PriorityReset	S
Progress	Ent
Recording	A
RecordingOptions	A
ReplicationDenominator	Clk
ReplicationNumerator	Clk
ReplicationTerminate	Clk
Required	L
RequiredReset	L
ResetStatistics	Glb
Residence	S,F,L
Residents	S,L
ResidentsIndex	Ent
ResidentsCount	S,L
ResidentsEval	S,L
Retract	S,L
Retracted	Ent
Revoking	S
RootName	S,F,Cc
RowIndex	Sc
RuleLinks	S
RuleLinksIndex	L
RuleResidents	S
RuleResidentsIndex	Ent
RuleSelectable	L
Run	Sc
ScriptEntity	Glb
ScriptObject	Glb
Seconds	Clk
SelectMember	Asm
SelectedLink	S
SelectedResident	S
Shielding	S
ShieldingReset	S
SimRunTime	Clk
SimStart	Clk
SimTermination	Clk
Simtime	Clk,Glb
Solitary	L
Source	Ent
Speed	Ent
Suspending	L
SwapResidents	S,L
Sweep	Asm
Terminate	Sc
TimeHour	Clk
TimeMinute	Clk
TimeSecond	Clk
TimeWeekday	Clk
Timing	S
TimingReset	S
Tracking	L
Travel	L
Travels	Asm
TravelsIndex	Ent
TravelReset	L
UniteDenominator	S,L
UniteEntity	S,L
UniteNumerator	S,L
Uniting	L
Upstream	S
Utilization	A,V
Value	Clk
Weeks	Clk
Years	Clk

* Procedure type:

S:	Server
L:	Link
F:	Fusion
D:	Distribution
A:	Attribute
V:	Variable
Ent:	Entity
Cc:	All components
Sc:	Schedule
Da:	Data association
Glb:	Global
Clk:	Clock
Asm:	Assembly

10.5 Renque scripting error code list

11000	Batch property could not be evaluated
11001	Batch property overflow
11002	Batch property must be positive
11003	Batch property could not be assigned
11005	Excess property could not be evaluated
11006	Excess property overflow
11008	Excess property could not be assigned
11010	Required property could not be evaluated
11011	Required property overflow
11013	Required property could not be assigned
11015	Travel property could not be evaluated
11016	Travel property overflow
11017	Travel property must be positive
11018	Travel property could not be assigned
11020	Departures property could not be evaluated
11021	Departures property overflow
11022	Departures property must be positive
11023	Departures property could not be assigned
11025	weight property could not be evaluated
11026	weight property overflow
11027	weight property must be positive
11028	weight property could not be assigned
11030	Timing property could not be evaluated
11031	Timing property overflow
11032	Timing property must be positive
11033	Timing property could not be assigned
11035	Capacity property could not be evaluated
11036	Capacity property overflow
11037	Capacity property must be positive
11038	Capacity property could not be assigned
11040	Priority property could not be evaluated
11041	Priority property overflow
11043	Priority property could not be assigned
11045	Shielding property could not be evaluated
11046	Shielding property overflow
11048	Shielding property could not be assigned
11049	Rndvar argument in Parameters procedure only available for Piecewise distributions
11050	distribution parameter could not be evaluated
11051	distribution parameter overflow
11052	distribution parameter out of range
11053	distribution parameter could not be assigned
11054	Index argument out of bounds for Parameters property of distribution component
11055	wrong number of arguments in distribution ParameterSet statement
11056	distribution component has invalid parameter
11057	schedule timing property could not be evaluated
11058	schedule timing property invalid
11059	schedule timing property overflow
11060	object property could not be evaluated
11061	object property evaluation overflow
11062	object property must be positive
11065	object property must be numeric
11068	rule property could not be assigned
11070	schedule timing must be numeric
11071	schedule timing property out of range
11072	schedule timing must be positive
11080	schedule timing clock overflow
11081	schedule recurrence expired
11085	AnimationSpeed property value could not be assigned
11091	wrong number of arguments in AttributeEntity function
11092	wrong number of arguments in HasAttributeEntity function
11093	object type has no Sampling property
11094	object type has no Value function
11096	object type has no AttributeEntity property
11097	object type has no HasAttributeEntity function
11098	object type has no Retract statement
11099	property not available for link objects
11100	not a Renque file
11103	application version older than project file version
11104	could not save Embedded spreadsheet data
11110	invalid argument StatParam for the Value function
11111	Data association does not have an assigned Attribute component
11112	Graph server has no attribute series

11113	SeriesItem argument has no matching data series
11114	Instance argument out of range
11115	wrong object type for AttribSeries argument
11117	Entity object required for AttributeEntity property assignment
11118	link Origin server does not match Scriptobject
11119	link Destination server does not match Scriptobject
11120	RuleResidents assembly available only for Scriptobject server
11121	RuleResidents assembly not available for current scripting incident
11122	RuleLinks assembly available only for Scriptobject server
11123	RuleLinks assembly not available for current scripting incident
11125	Icon property could not be assigned
11126	picture component was deleted
11130	wrong type in link property assignment
11131	wrong object type for PositionShift dx argument
11132	wrong object type for PositionShift dy argument
11135	RowIndex property not available
11136	ColumnIndex property not available
11137	cannot create new instance of running clock based or simulation state schedule
11138	invalid schedule instance reference
11139	schedule instance not running
11140	inconsistent distribution parameter set
11143	entity is undefined: Entry property unavailable
11144	entity is undefined: Departure property unavailable
11145	entity is undefined: attribute unavailable
11146	entity is undefined: Icon property unavailable
11147	entity is undefined: procedure unavailable
11148	entity is undefined: function unavailable
11149	entity is undefined: Speed property unavailable
11150	entity is undefined: Progress property unavailable
11151	rule component evaluates to an escort dispatching link
11152	rule component evaluates to a mandatory collecting link
11153	link selection by rule component failed
11154	link selected by rule component is not connected
11155	link selected by rule component has been excluded
11156	assigned rule component evaluates to a non-selectable dispatching link
11157	assigned rule component evaluates to a non-selectable collecting link
11158	invalid Criterion argument in Exclude procedure of RuleLinks assembly
11160	invalid Criterion argument in Exclude procedure of RuleResidents assembly
11161	cannot exclude all members in Exclude procedure of rule assembly
11167	invalid spreadsheet cell value for schedule item timing property
11168	incompatible spreadsheet cell value for distribution parameter
11169	invalid schedule item timing property
11170	invalid link number
11171	invalid Side argument
11172	invalid LinkFrom origin argument
11173	invalid LinkTo destination argument
11174	object type has no local variable
11175	object type cannot be used with entities
11176	object type has no Eval property
11177	wrong type in picture property assignment
11180	could not evaluate property: assigned variable contains a non-evaluating object
11181	non-Boolean Criterion argument in rule exclusion procedure for one or more members
11183	could not evaluate property: assigned attribute contains non-evaluating object
11184	array attribute requires index
11186	array variable requires index
11187	attribute index out of bounds
11188	variable index out of bounds
11189	object index out of bounds
11190	Could not execute EntityCreate function: Link not is not creating
11191	Could not execute EntityCreate function: Nested function call
11193	assigned string contains illegal character
11194	wrong type for Index argument
11195	only single statements allowed in scripts
11196	syntax error 'reserved string
11201	spreadsheet association lost
11202	Index argument out of bounds in Item procedure of Residents assembly
11205	Index argument out of bounds in Item procedure of Links assembly
11206	invalid spreadsheet cell value for distribution parameter
11207	Could not evaluate Property argument in RuleResidents Assess procedure for one or more residents
11208	Could not evaluate Property argument in RuleLinks Assess procedure for one or more links
11209	Index argument out of bounds in Item procedure of RuleLinks assembly
11210	clock properties calendar option is not applied: function unavailable
11211	clock properties time unit undefined: function unavailable
11214	invalid argument of statistical function
11215	spreadsheet application not ready for writing

11216	spreadsheet application not ready for reading
11217	invalid Row/Column argument for CellValue function
11218	wrong type in CellValue property assignment
11219	Embedded spreadsheet application not running
11220	Embedded worksheet does not exist
11225	wrong object type in component assignment
11226	entity is not a resident: Extraction failed
11230	invalid Recipient argument in Extract procedure
11231	first Position argument not available in SwapResidents procedure
11232	second Position argument not available in SwapResidents procedure
11233	Index argument out of bounds in Item procedure of RuleResidents assembly
11234	wrong type for Member argument in SelectMember procedure of RuleResidents assembly
11235	could not assign Escort dispatching link in the SelectMember procedure of RuleLinks assembly
11236	could not assign Mandatory collecting link in the SelectMember procedure of RuleLinks assembly
11237	wrong type for Member argument type in SelectMember procedure of RuleLinks assembly
11238	could not assign non-connected link in SelectMember procedure of RuleLinks assembly
11239	Member argument not an assembly member in SelectMember procedure of the RuleLinks the assembly
11240	could not assign non-selectable dispatching link in SelectMember procedure of RuleLinks assembly
11241	could not assign non-selectable collecting link in SelectMember procedure of RuleLinks assembly
11243	could not assign non-resident entity in SelectMember procedure of RuleResidents assembly
11244	Member argument not an assembly member in SelectMember procedure of RuleResidents assembly
11245	RuleResidents assembly not available for active servers
11246	RuleLinks assembly not available for Passive servers in Select collect incident
11247	resident selection by rule component failed
11248	resident selected by rule component has been excluded
11249	rule component evaluation result out of bounds
11258	Invalid Property argument in Assess procedure of RuleResidents assembly
11259	Invalid Property argument in Assess procedure of RuleLinks assembly
11260	invalid Param argument for Assess procedure of RuleResidents assembly
11261	invalid Param argument for Assess procedure of Residents assembly
11262	invalid Param argument for Assess procedure of RuleLinks assembly
11263	invalid Param argument for Assess procedure of Links assembly
11264	invalid Param argument for Assess procedure of Travels assembly
11266	Could not evaluate Property argument in assembly Assess procedure for one or more residents
11267	Could not evaluate Property argument in assembly Assess procedure for one or more links
11268	Invalid Property argument in Assess procedure of Residents assembly
11269	Invalid Property argument in Assess procedure of Links assembly
11270	invalid Criterion argument in Count procedure of RuleResidents assembly
11271	invalid Criterion argument in Count procedure of RuleLinks assembly
11272	invalid Criterion argument in Count procedure of Residents assembly
11273	invalid Criterion argument in Count procedure of Links assembly
11274	non-Boolean Criterion argument in RuleResidents Count procedure for one or more residents
11275	non-Boolean Criterion argument in RuleLinks Count procedure for one or more links
11276	non-Boolean Criterion argument in Residents Count procedure for one or more residents
11277	non-Boolean Criterion argument in Links Count procedure for one or more links
11278	Could not evaluate Criterion argument of assembly Exclude procedure for one or more residents
11279	Could not evaluate Criterion argument of assembly Exclude procedure for one or more links
11280	Could not evaluate Criterion argument of assembly Count procedure for one or more residents
11281	Could not evaluate Criterion argument of assembly Count procedure for one or more links
11283	Assembly procedure only available for RuleLinks and RuleResidents assemblies
11284	Assembly procedure only available for RuleLinks assemblies
11285	invalid Operation argument in Sweep procedure of RuleResidents assembly
11286	invalid Operation argument in Sweep procedure of RuleLinks assembly
11287	invalid Operation argument in Sweep procedure of Residents assembly
11288	invalid Operation argument in Sweep procedure of Links assembly
11289	invalid Operation argument in Sweep procedure of Travels assembly
11290	could not execute Operation argument of assembly Sweep procedure for one or more residents
11291	could not execute Operation argument of assembly Sweep procedure for one or more links
11292	could not execute Operation argument of assembly Sweep procedure for one or more entities
11293	invalid use of Void property
11295	Member argument out of bounds in SelectMember procedure of RuleLinks assembly
11296	Member argument out of bounds in SelectMember procedure of RuleResidents assembly
11300	Index argument out of bounds in Item procedure of Travels assembly
11302	invalid Criterion argument in Count procedure of Travels assembly
11303	non-Boolean Criterion argument in Travels Count procedure for one or more residents
11306	Invalid Property argument in Assess procedure of Travels assembly
11307	Could not evaluate Property argument in the Travels assembly Assess procedure for one or more entities
11308	could not assign entity Identifier property: invalid string
11309	could not assign entity Identifier property: identifier already assigned to another entity
11310	entity is not stored: Entry function unavailable
11311	entity is not stored in a server: Departure property unavailable
11312	Departure property could not be assigned
11313	entity not travelling: Progress function unavailable
11314	entity not travelling: Speed property unavailable
11315	entity has zero travel time: Speed property cannot be assigned

11317	Member object undefined
11318	SweepMember object undefined
11320	invalid Criterion argument in HasItem procedure of RuleResidents assembly
11321	invalid Criterion argument in HasItem procedure of RuleLinks assembly
11322	invalid Criterion argument in HasItem procedure of Residents assembly
11323	invalid Criterion argument in HasItem procedure of Links assembly
11324	invalid Criterion argument in HasItem procedure of Travels assembly
11325	non-Boolean Criterion argument in RuleResidents HasItem procedure for one or more residents
11326	non-Boolean Criterion argument in RuleLinks HasItem procedure for one or more links
11327	non-Boolean Criterion argument in Residents HasItem procedure for one or more residents
11328	non-Boolean Criterion argument in Links HasItem procedure for one or more links
11329	non-Boolean Criterion argument in Travels HasItem procedure for one or more links
11330	Could not evaluate Criterion argument of assembly HasItem procedure for one or more residents
11331	Could not evaluate Criterion argument of assembly HasItem procedure for one or more links
11335	random generator capacity exceeded
11337	Attribute entity is not recording: RecordingOption procedure unavailable
11338	object type has no Recording property
11339	object type has no RecordingOption property
11340	invalid OptionName argument in RecordingOption property
11345	Allocation property could not be evaluated
11346	Allocation property overflow
11347	Allocation property must be positive
11348	Allocation property could not be assigned
11349	Invalid Index argument in resource allocation procedure call
11350	Index argument server has no resource allocation requirement
11351	Index argument out of bounds in resource allocation procedure call
11353	ContentText procedure call requires Text style graph server
11354	Index argument out of bounds in ContentText procedure call
11355	object type has no ContentText property
11356	Server must be a Graph